Model PRS-1/PRS-2

"RASCAL" Technical Manual

Eberline

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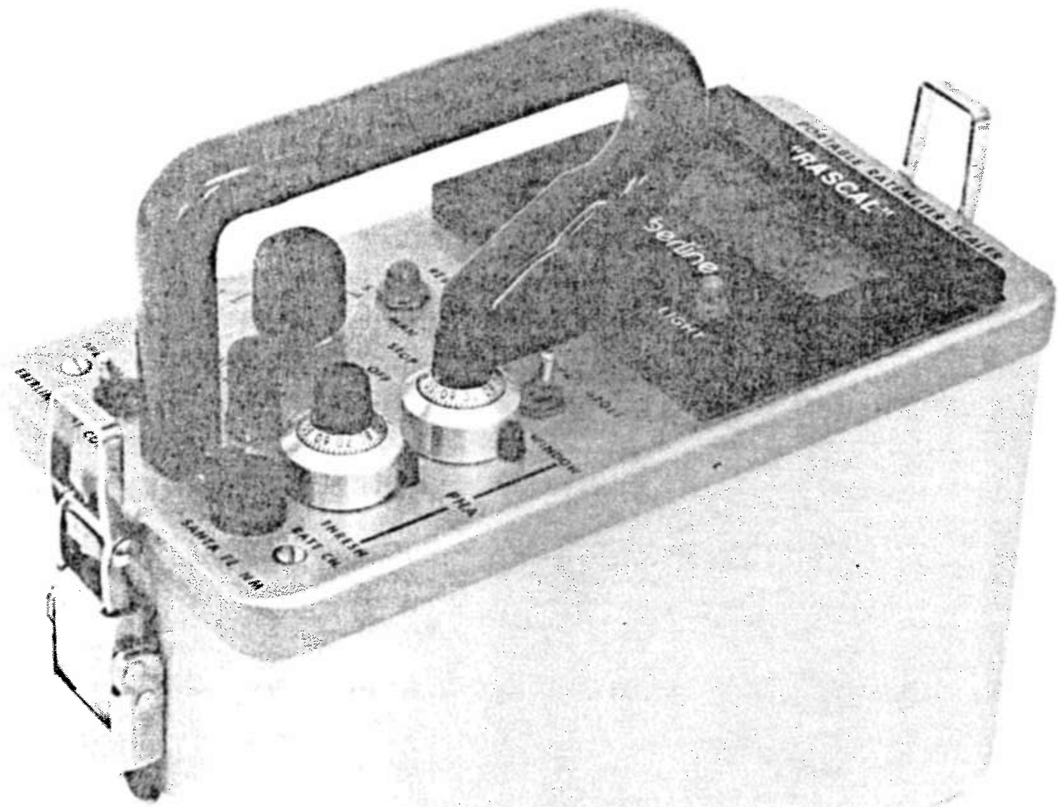

Figure 1-1. RASCAL, Model PRS-1

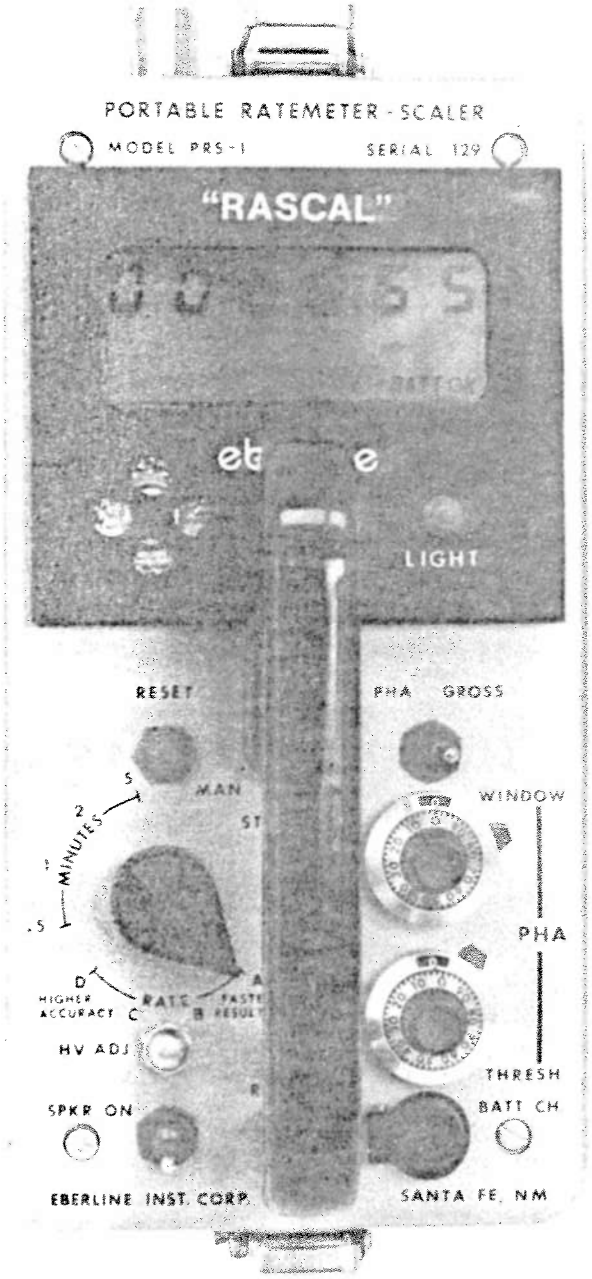

Figure 1-2. RASCAL, Model PRS-1

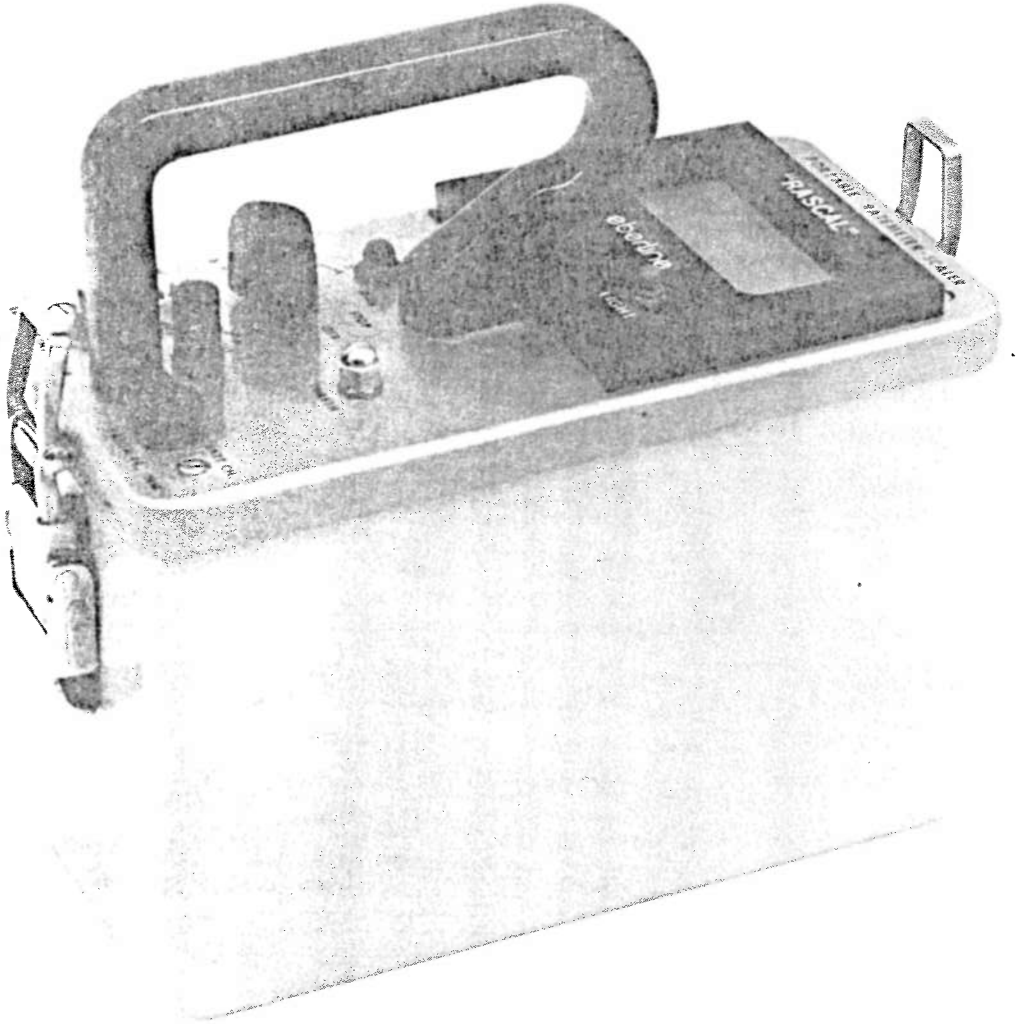

Figure 1-3. RASCAL, Model PRS-2

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The RASCAL, Models PRS-1 and PRS-2, is a complete system consisting of a variable high-voltage supply, charge-sensitive input amplifier, scaler, ratemeter, timer, six-decade digital liquid crystal display and a self-contained battery supply. The PRS-1 provides a single-channel pulse height analyzer, while the PRS-2 has a baseline discriminator only. All circuits are solid state with extensive use of CMOS integrated circuits to enhance reliability. All integrated circuits are plugged in for ease of maintenance.

The instrument is designed to be used with many different Eberline scintillation, Geiger-Mueller (G-M) and proportional detectors.

The instrument uses a liquid crystal display and low-power integrated circuit components to conserve battery power.

B. SPECIFICATIONS

1. High Voltage: The high voltage power supply is regulated, adjustable at the front panel from approximately 200 V to approximately 1500 V and can supply a 100 MΩ load. The supply (Eberline Model P-201A) is a plug-in module for ease of maintenance.

2. Amplifier: Charge-sensitive input allowing very high input sensitivity with excellent noise rejection. Sensitivity is approximately 2×10^{-14} to 2×10^{-13} C (approximately equivalent to from 1 mV to 10 mV on a voltage-sensitive input). Overall sensitivity adjustable by an internal gain control.

3. Threshold (PRS-1 only): Adjustable by a calibrated ten-turn front panel control from 0 to 1 V. (PRS-2 has front-panel-adjustable single-turn threshold control.)

4. Window (PRS-1 only): Adjustable by a calibrated ten-turn front panel control from 0 to 1 V, always constant above threshold. A front panel control allows the window to be disabled and a gross count to be obtained.

5. Instrument Resolution: Less than 2 microseconds (μs), depending upon input wave shape.

6. Scaler: In the scaler mode six decades of information are displayed. Continuous updating of the display or updating at the completion of the timed period is selectable by an internal switch.

7. Timer: Preset times of 0.5, 1, 2 and 5 minutes plus manual (*MAN*) and *STOP*. The timer is part of the instrument's clock system and is referenced to a crystal oscillator with an accuracy of 0.01 percent.

8. Ratemeter: In the ratemeter mode six decades of information are displayed. The rate is determined by sampling 10, 100, 1000 or 10,000 events as selected by the range switch on the front panel. The compute time for the ratemeter is fixed at 3 seconds. The sample time is dependent on the event rate and the selection of the range switch position. The ratemeter range is from 10 counts per minute (cpm) to 999,999 cpm.

9. Dose Ratemeter: Internal adjustments for various detectors. Rate multiplier ranges of 9.99 to 0.00001 and rate divider ranges of 99,900 to 0.1 are available. Legends of mrem/h, mR/h or R/h may be displayed.

10. Reset Rate: Adjustable from approximately 1 second to approximately 8 seconds. An *OFF* position on the control is also provided to disable this feature.

11. Reset: Resets scaler, ratemeter and internal clock to zero. Starts time in scaler mode.

12. Gross-PHA (PRS-1 only): *GROSS* counting or pulse height analysis (*PHA*) is selectable by a front panel switch.

13. Speaker: Internal, with *OFF-ON* switch control.

14. Battery Supply: Three battery supplies are available for the PRS-1 — a rechargeable Gel-Cell® (standard), a BP-1 battery pack with five D-cell rechargeable Ni-Cd batteries (optional), or a BP-1 battery pack with five D-cell primary (C-Zn, alkaline, etc.) batteries (optional). Battery life is approximately 300 hours for C-Zn, 380 hours for alkaline, 200 hours for Ni-Cd and 75 hours for Gel-Cell batteries.

15. Battery Charger Connector: Miniature phone.

16. Light: Display illumination is controlled by push button for low ambient light conditions.

17. Detector Connector: Eberline type CJ-1, waterproof.

18. Mechanical

a. Size: 7¾ inches high x 9½ inches long x 4 inches wide (19.7 cm x 24.1 cm x 10.2 cm).

b. Weight: Approximately 5 pounds (2.27 kg) with Gel-Cell battery.

19. Temperature: Operational from 0°F to 140°F (-18°C to 60°C) with less than ±1 percent high voltage change typical and less than ±20 percent amplifier gain change typical.

20. Battery Charger: Battery chargers for Ni-Cd and Gel-Cell batteries are provided. Charge time is approximately 10 to 16 hours.

21. High Voltage Meter: Reads high voltage power supply from approximately 500 V to approximately 1500 V with a nominal accuracy of ±5 percent.

22. Battery Condition Indicator: *BATT OK* is displayed until batteries are exhausted.

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. External

a. Detector: Connection to detector. Eberline CJ-1 waterproof connector. Mates with Eberline CP-1 connector.

b. *RESET:* Push button resets all appropriate circuitry to zero and starts counting sequence.

c. Function Switch: Rotary switch that selects mode of instrument function; ratemeter or scaler and ranges for each function. The ratemeter mode has four ranges to provide a selection of accuracy of reading and speed of response. The scaler mode has four timed ranges: 0.5 minutes, 1.0 minutes, 2 minutes and 5 minutes plus *MAN* and *STOP*. The function switch also has an *HV* position for indicating high voltage of the internal high voltage power supply and an *OFF* position for turning the instrument off.

d. *PHA-GROSS* (PRS-1 only): Switch to select gross counting or pulse height analysis (*PHA*).

e. *THRESH* (threshold) (PRS-1 only): Ten-turn calibrated dial for setting and changing base line sensitivity (PRS-2 — locking single-turn non-calibrated control.)

f. *WINDOW* (PRS-1 only): Ten-turn calibrated dial for setting and changing range of pulse heights to be counted.

g. *RESET RATE:* Controls the reset rate of the scaler function. The control has an *OFF* position in the extreme counterclockwise position to disable this feature.

h. *HV ADJ:* Single-turn control for setting and changing the high voltage power supply.

i. *SPKR-ON* (speaker on): Switch for enabling the internal speaker.

j. *LIGHT:* Push button activates a lamp for reading the display in low ambient light.

k. *BATT CH:* Connector for use of an external battery charger when using rechargeable batteries.

2. Internal

a. *SCALER* (Calibration Board): A two-position switch used to select scaler display. In the *STORE* position the data displayed is updated at the completion of the timed cycle. In the increment *(INCR)* position, the data is displayed, or updated, continuously.

b. *CALIB*(Calibration Board): A two-position switch, used to select the calibration function when the instrument is used in the ratemeter mode. When the switch is in the *IN* position, the three calibration function switches are operational. When the switch is in the *OUT* position, the calibration function is not operational. In this case the display is counts per minute.

c. Calibration Function Switches (Calibration Board): Three rotary switches used to calibrate the instrument to the probe used with the instrument. Refer to Section IV for calibration.

d. Legend Switches (Display Board): Eight switches that are used to select the legend or legends to be displayed when the instrument is operated in the ratemeter mode. The selections are (1) decimal point 1; (2) decimal point 2; (3) decimal point 3; (4) counts per second; (5) R/h; (6) mR/h; (7) cpm and (8) mrem/h. When the switch is in the *ON* position the legend will be displayed. When the switch is in the *OFF* or *OPEN* position the legend will not be displayed.

e. VCO Frequency (Main Board): A potentiometer adjustment for the high voltage display. Refer to Section IV for adjustment.

f. VCO Offset (Main Board): A potentiometer adjustment for the high voltage display. Refer to Section IV for adjustment.

g. Battery OK Adjustment (Main Board): A potentiometer adjustment for the *BATT OK* display. Refer to Section IV for adjustment.

h. Amplifier Gain Control (P-8B Board): A trimmer adjustment for amplifier gain adjustment. Refer to Section IV for adjustment.

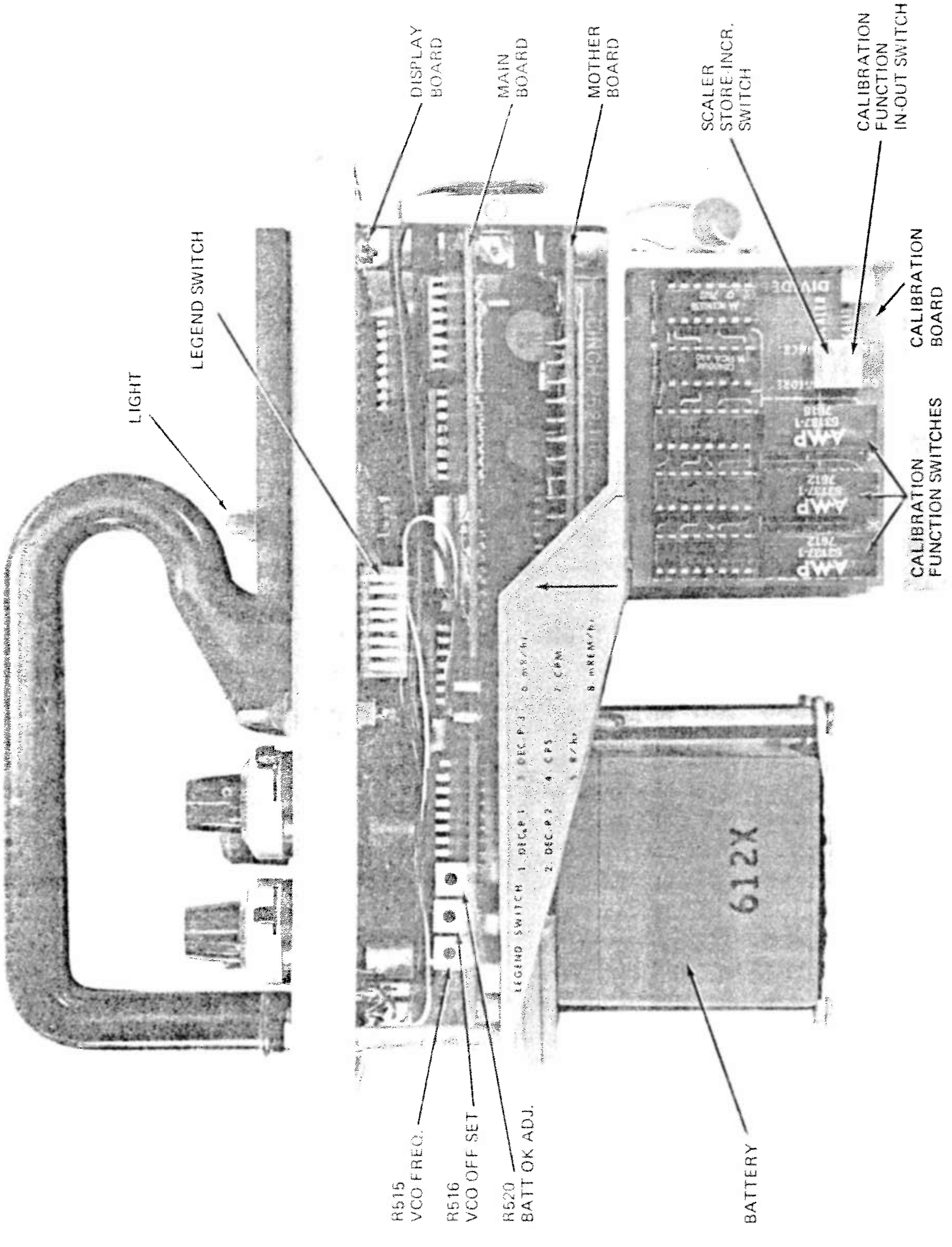

Figure 2-1. Interior Side View

B. PREPARATION FOR USE

1. The instrument should be checked for physical damage.

2. If the instrument is equipped with rechargeable batteries, it is advisable to recharge the batteries if the instrument has not been used recently.

NOTE

The instrument will not operate when the batteries are being charged.

CAUTION

Do not overcharge the batteries. Damage to the equipment could occur if the batteries are overcharged.

CAUTION

Do not attempt to recharge the batteries with a charger that is not designed to be used with the batteries installed in the instrument.

Do not attempt to recharge primary batteries (C-Zn, etc.) that are not designed to be recharged.

3. Set the controls as follows:

a. *HV ADJ:* Counterclockwise.

b. *THRESH:* 5.00 for PRS-1. Approximately midrange for PRS-2.

c. *PHA GROSS:* Gross for PRS-1. Not applicable for PRS-2.

d. *RESET RATE:* Counterclockwise into the switch detent.

e. *SPEAKER:* Off.

C. OPERATIONAL CHECK

CAUTION

The high voltage power supply in this instrument produces voltages that can cause a severe electrical shock. Use caution when connecting cables to the detector connector and when the instrument is out of its case.

1. Turn range switch to the *HV* position. The display should indicate at approximately a 1-second rate and the *BATT OK* legend should be displayed. If the *ERROR* legend is displayed, press the *RESET* switch; the *ERROR* legend should extinguish.

NOTE

The value on the displayed digits is not significant with the *HV ADJ* in the counterclockwise position.

2. Press the *LIGHT* switch. The display light should be visible and the *BATT OK* legend should remain displayed.

NOTE

If the *BATT OK* legend disappears when the light switch is pressed and reappears when the switch is released, a marginal battery is indicated. If the batteries are of the rechargeable type, recharging the battery is advisable. If the batteries are not of the rechargeable type, replacing the batteries is advisable.

3. Return the range switch to the *OFF* position.

D. OPERATING THE INSTRUMENT

1. Mode of Operation

a. Ratemeter Mode: In the ratemeter mode the instrument averages the counts, or events, received from the detector, computes the value and displays the information on the six-digit liquid crystal display. The number of counts averaged by the instrument depends on the position of the range switch and is shown in Table 2-1. The time required for an average to be made is dependent upon selected number of counts to be averaged and the rate at which they occur. Range switch position *A* requires the least number of counts to be averaged and therefore provides faster results. The accuracy of the reading depends on the total number of counts averaged (see Section II E.). Range switch position *D* requires the greatest number of counts to be averaged and therefore provides higher accuracy. Range switch positions *B* and *C* offer a selection between faster results and higher accuracy. The *COUNT* legend on the liquid crystal display indicates that the instrument is accumulating counts to be averaged.

After the selected number of counts has been accumulated, the instrument computes the value and displays the information. The time required for computation is fixed at three seconds. The *COUNT* legend on the display is extinguished when the selected number of counts has been accumulated, and the *COMPUTE* legend will appear to indicate that the instrument is computing the value. The value displayed on the liquid crystal display is updated at the completion of the computation.

The instrument is limited in the time required to accumulate the number of counts selected. If the time

SWITCH POSITION (RATE)	NUMBER OF COUNTS OR EVENTS AVERAGED	INSTRUMENT TIME LIMITATION
A	10	1.67 minutes
B	100	16.7 minutes
C	1,000	167 minutes (2.78 hours)
D	10,000	1670 minutes (27.8 hours)

Table 2-1. Range Switch — Ratemeter Functions

required exceeds the limitations of the instrument the *ERROR* legend will be displayed. The time limitations are shown in Table 2-1. To clear the *ERROR* indication and reset the instrument, depress the *RESET* switch.

Example: With the range switch in the *B* position, the instrument will accumulate 100 counts, compute the value, display the information on the liquid crystal display and repeat this operation. If the 100 counts are received in 5 seconds, the *COUNT* legend will be displayed for 5 seconds, the *COMPUTE* legend will be displayed for 3 seconds and the display will be updated with the new information. The total time required would be 8 seconds and then the operation will repeat. If 100 counts were not accumulated in 16.7 minutes the *ERROR* legend would be displayed.

NOTE

The *COUNT* legend will not be displayed until a count has occurred. The time limitation is calculated from the first count. If the detector is in a very low radiation field there may be a noticeable delay between the completion of the computation and the appearance of the *COUNT* legend.

The data displayed in the ratemeter mode is dependent on how the instrument is programmed. Refer to Section IV B. for calibration and programming.

b. Scaler Mode: Four timed positions; 0.5, 1, 2 and 5 minutes, plus manual (*MAN*) and *STOP* positions are available on the range switch for scaler operation. The display will be in counts, or events, and will be continuously (increment) displayed or updated (store) at the completion of the selected time, depending on a position of the internal *SCALER* switch (calibration board). The *COUNT* legend will be displayed during the timed interval.

2. G-M Detectors

a. Adjust the high voltage to the operating voltage of the detector being used. An *HV* position on the range switch is available for measuring the high voltage.

CAUTION

Use care not to over-voltage the G-M tube as permanent damage to the detector may result.

b. Connect the detector to the detector connector.

c. Set the *THRESH* control to 5.0. This reduces the chance of noise from the G-M tube (PRS-1 only; for PRS-2 set *THRESH* to mid-range).

d. Set the *GROSS-PHA* switch (PRS-1 only) to *GROSS*. (No pulse height information is available from the G-M detector.)

e. Place the range switch in the desired position, press the *RESET* switch, and expose the detector to a check source. The instrument is ready for operation.

3. Gross Counting with Scintillation Detectors

a. Connect the detector to the detector connector.

b. Set the *THRESH* control to 0.3 (PRS-1 only). (For PRS-2 set *THRESH* to an input sensitivity of approximately 10 mV.)

c. Set the *GROSS-PHA* switch to *GROSS* (PRS-1 only).

d. With the detector exposed to a radiation source of the isotope to be counted, plot a plateau of counts vs. high voltage setting. See Figure 2-2.

e. Remove the radiation source and repeat step d. for background radiation.

f. Set *HV ADJ* to a position on the plateau just below the increase of background counts.

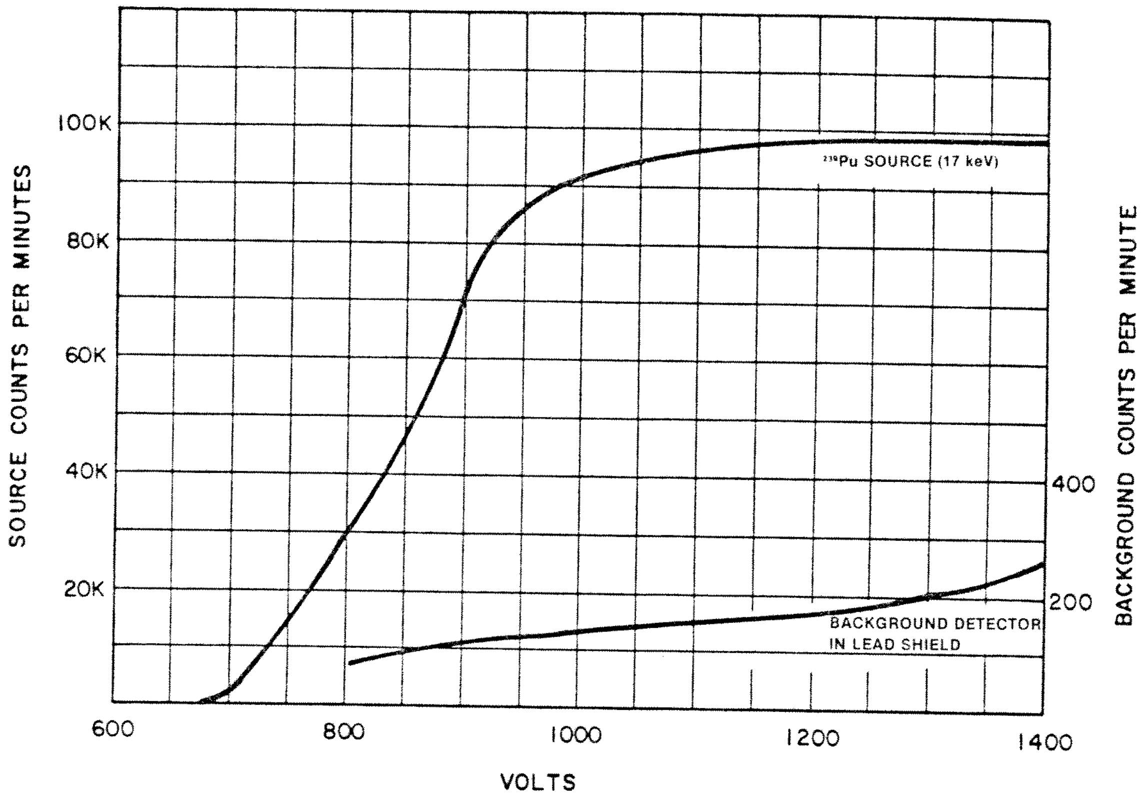

Figure 2-2. Typical High Voltage Plateau with PG-2 Detector (10763-B85)

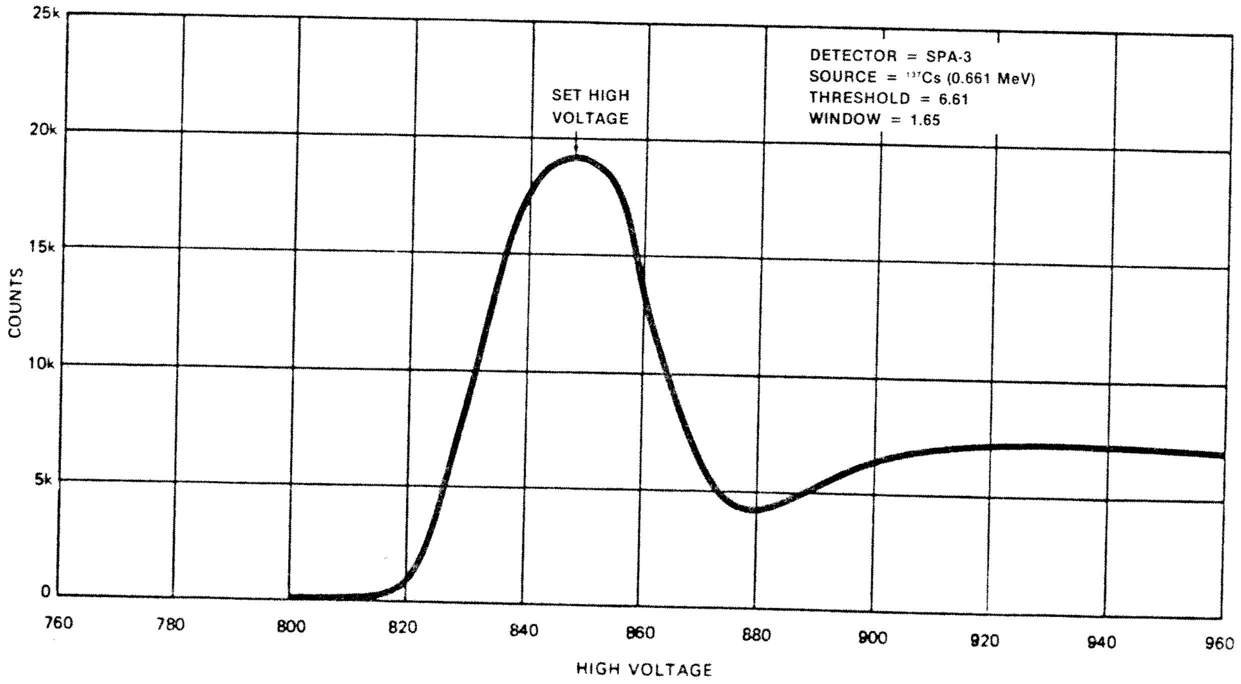

Figure 2-3. Typical Pulse Height Spectrum vs. High Voltage (10763-B86)

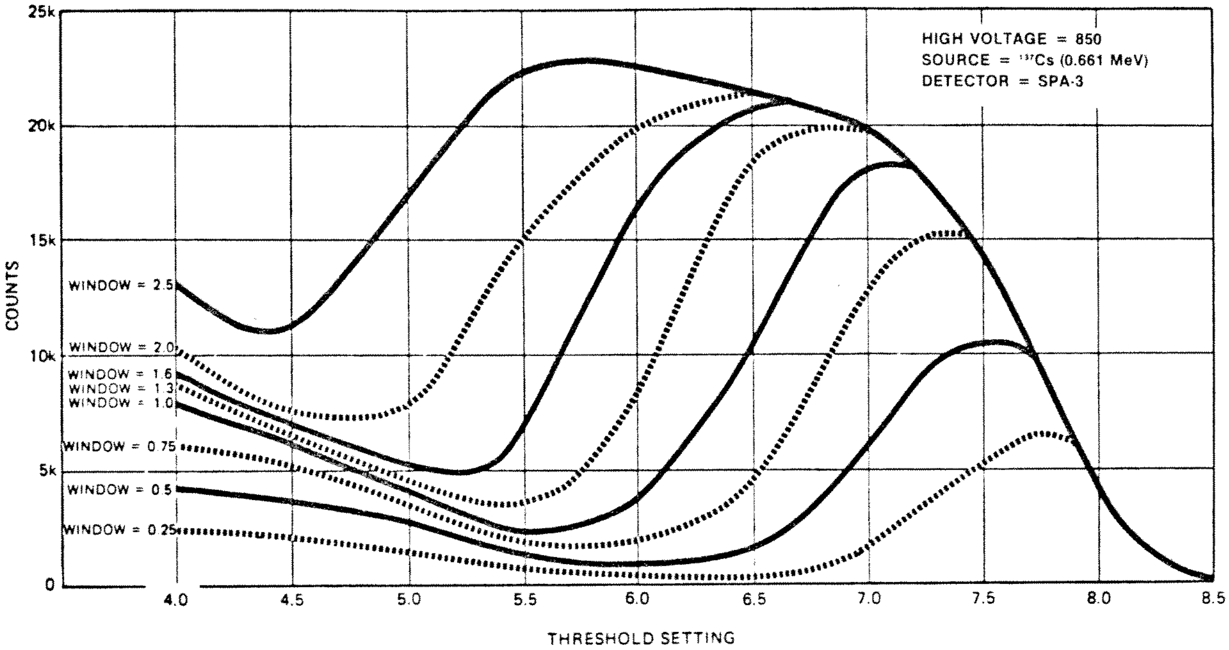

Figure 2-4. Typical Pulse Height Spectrum vs. Threshold Setting (10763-B87)

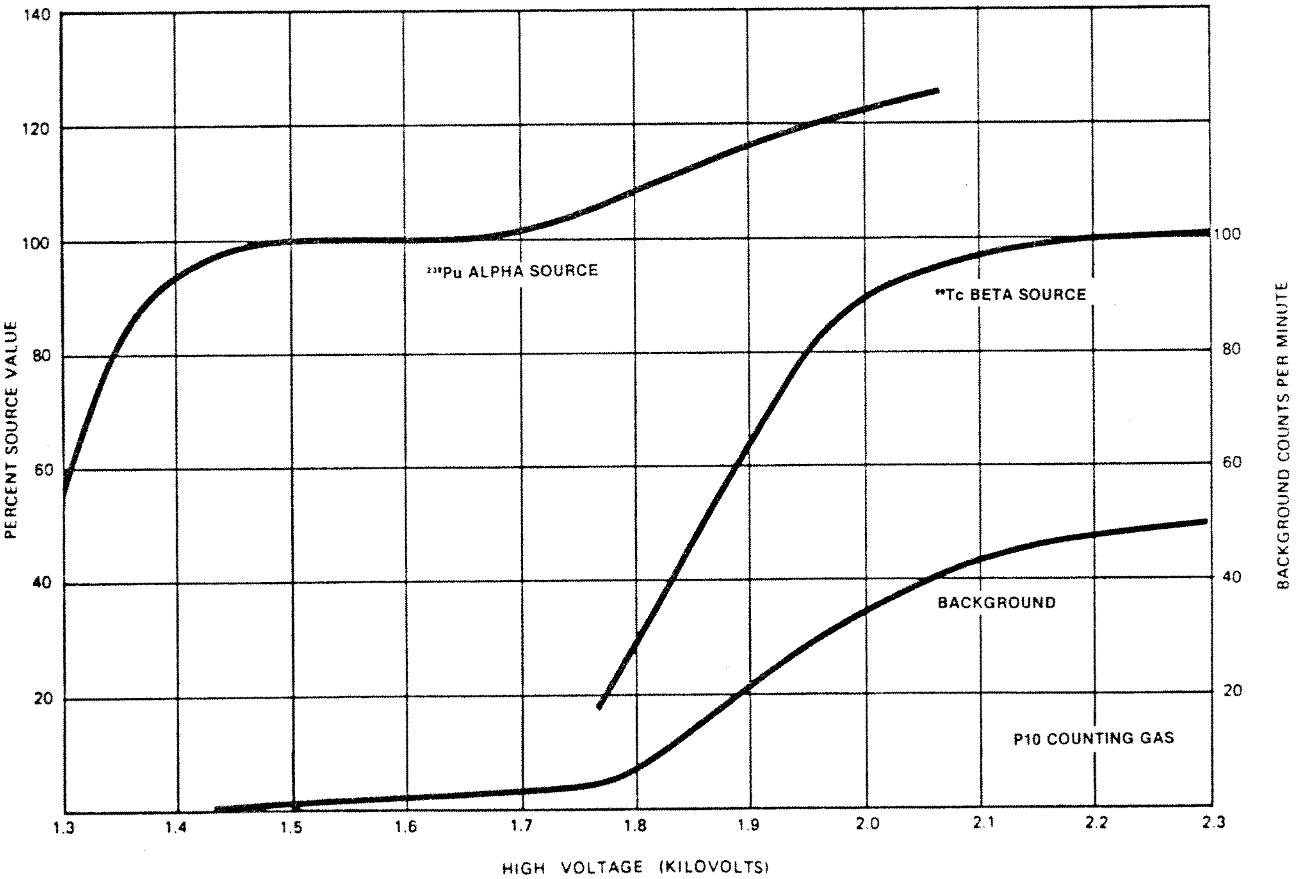

Figure 2-5. Typical Plateau with FC-2 Detector (10763-B88)

4. Pulse Height Analysis with Scintillation Detectors (PRS-1 only)

a. Adjust the *HV ADJ* to the maximum counterclockwise position.

b. Place the *PHA-GROSS* switch to *PHA*.

c. Connect the detector to the detector connector, and expose the detector to a radiation source which emits the energy of interest.

d. Adjust the *THRESH* control to the desired position for the energy being used.

e. Set the *WINDOW* control to 25 percent of the *THRESH* control setting.

f. Plot a curve of counts vs. high voltage. See Figure 2-3.

g. Adjust the high voltage for the peak reading.

h. To optimize window width, plot several curves of counts vs. *THRESH* setting with wider and narrower *WINDOW* settings and choose the one best suited. See Figure 2-4. If desired, adjust high voltage to obtain the maximum reading at the *THRESH* and *WINDOW* setting selected.

5. Proportional Detectors

a. Set the *THRESH* control to 0.10 for PRS-1, 2 mV for PRS-2, and the *PHA-GROSS* switch to *GROSS* (PRS-1 only).

b. Plot a curve of counts vs. high voltage with the detector exposed to an appropriate radiation field. See Figure 2-5.

NOTE

> The maximum high voltage on the standard PRS-1 is approximately 1500 V. This may not be high enough to reach the plateau of a proportional detector. A voltage regulator tube may be added to the P-201A high voltage supply to increase the maximum high voltage up to 3000 V if necessary. Resistor R-310 must also be changed if the *HV* display feature is to be used. See Section IV E.2.

c. Remove the detector from the radiation source and plot a background curve. See Figure 2-5.

d. Adjust the high voltage for a point on the plateau below the increase of the background count. See Figure 2-5.

e. The instrument is now ready for use.

E. PRACTICAL CONSIDERATIONS OF COUNTING RANDOM EVENTS (RADIOACTIVITY)

1. Statistical Deviation

When the total number of counts recorded from a radioactive source is small, the number can be considerably different from the average source value due to statistical deviation.

The radiation of particles from a source is random in nature and the laws of probability apply. From a determined number of counts, the following equations can be used to calculate the deviation to be expected from the average source value.

A standard deviation (SD) is defined as the square root of the average total number of counts (N_A). The symbol for this is σ. Thus,

$$SD = \sigma = \sqrt{N_A} \qquad (2\text{-}1)$$

Any determination (N) on a sample will be within a certain deviation of the average, a fixed percent of the time, as listed below.

$N = N_A \pm 0.674\sigma$ 50 percent of the time (2-2)

$N = N_A \pm \sigma$ 68 percent of the time (2-3)

$N = N_A \pm 2\sigma$ 95 percent of the time (2-4)

$N = N_A \pm 3\sigma$ 99.7 percent of the time (2-5)

Example A: A 2500 cpm source is counted 100 times for 1 minute each.

From Equation (2-1), $SD = \sigma = \sqrt{2500} = 50$ cpm.

The distribution of the individual counts will be as follows:

From Equation (2-2), 50 counts will be within 2500 ±34, or 2466 to 2534 cpm.

From Equation (2-3), 68 counts will be within 2500 ±50, or 2450 to 2550 cpm.

From Equation (2-4), 95 counts will be within 2500 ±100, or 2400 to 2600 cpm.

From Equation (2-5), nearly all counts will be within 2500 ±150, or 2350 to 2650 cpm.

There is always the possibility that a count will be far away from the average, but this will happen only a small percentage of the time.

2. Confidence Level

When the average count from a sample is not known and the accuracy of one determination must be specified, a confidence level must be used. Confidence level corresponds to the percentages in Equations (2-2) through (2-5). At 50 percent confidence level, any one determination will be within $\pm 0.674\sigma$ of the average count. At the 95 percent confidence level, any one determination will be within $\pm 2\sigma$ of the average count.

Example B: A one-minute determination of a sample reads 1747 counts. The standard deviation (σ) is 42. The accuracy of the determination can be specified as follows:

1747 ±28 cpm 50 percent confidence level or 1747 ±84 cpm 95 percent confidence level.

The 95 percent confidence level is in fairly common usage; however, any level can be used as long as it is specified.

3. Error in Combining Two Determinations

If the background count is comparable to the sample count, considerable error can be had in the solution when the background is subtracted out. The following formula applies:

$$R = R_S - R_B \pm 2\sqrt{\frac{R_S}{T_S} + \frac{R_B}{T_B}}$$

95 percent confidence level

R = Net count rate of sample in counts per minute.

R_S = Count rate of sample plus background in counts per minute.

R_B = Count rate of background in counts per minute.

T_S = Time that sample plus background were counted in minutes.

T_B = Time that background was counted in minutes.

Example C: Background count is 20 counts in 5 minutes, and sample plus background count is 100 counts in 5 minutes. So,

$R_S = 100/5 = 20$ cpm

$R_B = 20/5 = 4$ cpm

$T_S = 5$ minutes

$T_B = 5$ minutes

$$R = 20 - 4 \pm 2\sqrt{\frac{20}{5} + \frac{4}{5}} = 16 \pm 2\sqrt{4.8} = 16 \pm 4.4 \text{ cpm}$$

at 95 percent confidence level.

To get the highest accuracy in the minimum amount of time, the sample counting time (T_S) and background counting time (T_B) should be distributed according to the following formula:

$$\frac{T_S}{T_B} = \sqrt{\frac{R_S}{R_B}}$$

4. Resolving Time Error

When counting samples with a high count rate, the determination can be in error because of the finite resolving time of the counting system. The resolving time of a counter can be determined by counting two sources of approximately the same value individually and then together and applying the following formula:

$$\tau = \frac{R_1 + R_2 - R_{12}}{2(R_1 R_2)}$$

where:

τ = resolving time (seconds)

R_1 = counting rate, source 1 (counts per second)

R_2 = counting rate, source 2 (counts per second)

R_{12} = counting rate, source 1 + 2 (counts per second)

When the resolving time is known, an observed count can be corrected by applying the following formula:

$$R = \frac{Ro}{1 - Ro\tau}$$

where:

R = true counting rate (counts per second)

Ro = observed counting rate (counts per second)

τ = resolving time (seconds)

NOTE

Due to simplification of the above equations, the accuracy of the correction is limited if the correction exceeds about 20 percent.

SECTION III
THEORY OF OPERATION

A. GENERAL

The internal high voltage power supply develops high voltage for the detector. When radiation reacts in the detector, negative pulses are generated. The pulses are coupled to the P-8B amplifier-discriminator for detection, for pulse height analysis (PRS-1 only), and for generation of a logic signal for counting. The instrument has two selectable methods for counting the signals — scaler and count ratemeter.

In the scaler mode the signals are counted for a selected time period and the count for that period is displayed. See Figure 3-1.

In the ratemeter mode a selected number of signals are accumulated in the input register at the same time clock signals are accumulated in the period register. When the selected number of signals has been accumulated in the input register, a logic signal is generated and the instrument computes the count rate by solving the following equation.

$$\text{Frequency (count rate)} = \frac{\text{Constant}}{\text{Period (Time)}}$$

The constant is a clock signal supplied to the divide-by-N register and the period is the information in the period register. The results, in counts per minute, are supplied through a calibration function to the counts register for display. Two calibration function plug-in boards are available (only one is supplied with the instrument) to convert the count rate information into working units information. See Figures 3-2 and 3-3.

A voltmeter to read the high voltage of the instrument is also included in the instrument. See Figure 3-4.

B. FUNCTIONAL THEORY

1. High Voltage Supply (P-201A) Refer to Figure 6-9

This unit consists of a controlled oscillator (Q101), voltage step-up and rectification (T101), high voltage division (R106, R107, R108, R109 and R112), differential amplifier (Q104, Q105, Q106), amplifier (Q103), and oscillator control (Q102).

The regulation circuit is in balance when the voltages on Q104 and Q105 gates are equal. The high voltage will be a multiple of the voltage on the gates, approximately 475 times. The high voltage is varied by varying the voltage on the reference side (gate Q104) with R604, *HV ADJUST*. R604 is used as a voltage divider with 3.5 Vdc supplied to it by zener diode CR305. Refer to Figures 6-1, 6-2, and 6-3 for more detail. As the reference is increased, the differential amplifier is unbalanced, which increases the level of the oscillator and the high voltage output. This puts more current through the high voltage reference resistors, which increases the voltage on the sensing input (Q105 gate) and rebalances the circuit at a higher voltage.

A heavier load tends to lower the high voltage, unbalancing the differential amplifier. This increases the level of the oscillator to maintain the original output.

Changes in power supply voltage are compensated by R110.

The differential amplifier is a matched pair (Q104, Q105) for temperature stability. Q106 is a current source.

The maximum output can be increased by replacing R112 with a regulator tube. The minimum high voltage will then be approximately 100 V higher than the regulator tube voltage, and the maximum will be approximately 1200 V above the regulator tube voltage.

2. Amplifier-Discriminator (P-8B) Refer to Figure 6-8

Transistors Q1 and Q2 form a charge-sensitive amplifier whose output is proportional to the charge input from the detector. The feedback capacitor C4 (variable) determines the sensitivity of this circuit. Constant-current source CR1 sets Q1 bias current and, due to its high impedance, provides a very high voltage gain from Q1. Q2 is an emitter follower which provides a low output impedance from the amplifier. CR2 is used to protect the input of Q1. C3 ac-couples the amplified pulse (positive going) to the two voltage comparators (A1-T, A1-W) that serve as threshold and window discriminators. Here the pulse is compared against two reference voltages set by the front panel controls. If the pulse exceeds the reference voltage, an output pulse is generated.

Three possible conditions can exist. First, if the pulse is smaller than the threshold reference voltage, there is no output pulse to the dual D type flip-flops A2-T and A2-W. If the pulse exceeds the threshold but does not exceed the window reference, only a pulse to A2-T is generated. If the pulse exceeds both the threshold and window, then both A2-T and A2-W will receive a pulse. The output of the threshold flip-flop is normally high, the output of the window flip-flop is normally low. Without an input pulse, these stages do not change and the NOR gate A3-1 in the next stage does not change.

If the second condition exists and a threshold pulse appears, A2-T output changes from high to low. A2-W is already low, and with two lows now at the input to A3-1, its output goes high. As A2-T goes low, it also discharges C7 through R9 causing A3-3 to change state momentarily. A positive pulse from A3-3 is fed back to the resets on A2-T and A2-W, restoring the initial conditions to the flip-flop. The output from A3-1 drives A3-2. This output from A3-2 is a negative going pulse which is available at pin J for further processing. This pulse is modified by a pulse stretcher made up of C6, R10 and A3-4 to insure a uniform pulse for counting. Its duration is approximately 1 μs.

If the third possible condition exists and both flip-flops change state, a reset pulse is generated by A3-3, but since there is still a high and a low state applied to A3-1, its output does not change state, and a countable pulse is not generated. A *PHA-GROSS* switch is available on the front panel of the PRS-1, which ties the data line of the A2-W flip-flop either high or low. In the *GROSS* position, this flip-flop is inhibited and all pulses generated by the threshold comparator A1-T will pass through the system.

3. Clock Register

The clock register (main board) provides all of the timing signals used in the instrument and is crystal controlled for both accuracy and stability over wide ranges of temperature and battery voltage.

The oscillator uses a quartz crystal (operating in the fundamental mode of 2000 kHz) and two sections of quad NOR gate A501. One section is used as the active element of the oscillator and the other section is used as a buffer stage. The oscillator drives serially connected dual-decade counters A502, A503, A513, one section of counter A504 and time base generator A505. Timing signals are supplied for the counters and time base generator in the register. All counters and the time base generator are reset from a common clock register reset bus.

4. Input Register

The function of the input register (main board) is to count a preset number of input counts, or detector events, and then provide a logic signal for data computation. The preset number of counts is selected by the range switch and is shown in Table 3-1. The input register is operable only when the range switch is in the *RATE* positions.

The negative logic signals from the P-8B amplifier are supplied through NOR gate A508 to serially connected dual-decade counters A509 and A510, and to the second section of dual flip-flop A511. The first logic signal from the P-8 sets the second flip-flop to enable the counters, and to provide a negative enable signal to the period register and a positive enable signal to the *COUNT* legend driver. When the selected number of counts has been accumulated, the first flip-flop is reset, which resets the second flip-flop and removes both enable signals. The reset lines of the counters, the set line of the first flip-flop, and the reset line of the second flip-flop are connected in common for register reset. Selection of the preset number of counts by the range switch is accomplished by supplying a dc level to multiplexer A512. See Table 3-1 for the dc levels and the input register counts.

5. Period Register

The purpose of the period register is to establish the period for the selected number of input counts, or detector events, and to program the divide-by-N register with the period information. The period is computed by accumulating clock signals during the time the input register is actively accumulating input counts. The clock frequency to be counted by the period register is shown in Table 3-1.

Three dual-decade counters (A517, A523 and A527) are serially connected to provide six decades of register. The BCD output of each counter is supplied to divide-by-N counters in the divide-by-N register. The counters, enabled by a negative enable signal from the input register, accumulate clock signals until the enable signal is removed. All counters are connected to the reset bus for simultaneous reset.

To provide higher display resolution for high input count rates, without requiring excessive compute time or battery power, an auto-range circuit is provided. The auto-range function is accomplished by supplying a clock signal to the computers at a frequency 10 times the normal rate, for input count rates greater than 60,000 counts per minute (cpm), and automatically switching to the normal clock frequency at input count rates less than 60,000 cpm. To compensate for the higher clock frequency, the count information is supplied to digit two of register, and switched to digit one for the low clock frequency. A functional diagram of the auto-range circuit is shown in Figure 3-5.

An overflow condition can exist if the selected number of counts to be counted in the input register do not occur within the time period required to fill the six counters of the period register. In this condition the displayed count rate will be in error. To warn the operator of this condition an *ERROR* legend will be displayed. Table 3-2 lists the overflow conditions.

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THEORY OF OPERATION

A. GENERAL

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If the third possible condition exists and both flip-flops change state, a reset pulse is generated by A3-3, but since there is still a high and a low state applied to A3-1, its output does not change state, and a countable pulse is not generated. A *PHA-GROSS* switch is available on the front panel of the PRS-1, which ties the data line of the A2-W flip-flop either high or low. In the *GROSS* position, this flip-flop is inhibited and all pulses generated by the threshold comparator A1-T will pass through the system.

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4. Input Register

The function of the input register (main board) is to count a preset number of input counts, or detector events, and then provide a logic signal for data computation. The preset number of counts is selected by the range switch and is shown in Table 3-1. The input register is operable only when the range switch is in the *RATE* positions.

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5. Period Register

The purpose of the period register is to establish the period for the selected number of input counts, or detector events, and to program the divide-by-N register with the period information. The period is computed by accumulating clock signals during the time the input register is actively accumulating input counts. The clock frequency to be counted by the period register is shown in Table 3-1.

Three dual-decade counters (A517, A523 and A527) are serially connected to provide six decades of register. The BCD output of each counter is supplied to divide-by-N counters in the divide-by-N register. The counters, enabled by a negative enable signal from the input register, accumulate clock signals until the enable signal is removed. All counters are connected to the reset bus for simultaneous reset.

To provide higher display resolution for high input count rates, without requiring excessive compute time or battery power, an auto-range circuit is provided. The auto-range function is accomplished by supplying a clock signal to the computers at a frequency 10 times the normal rate, for input count rates greater than 60,000 counts per minute (cpm), and automatically switching to the normal clock frequency at input count rates less than 60,000 cpm. To compensate for the higher clock frequency, the count information is supplied to digit two of register, and switched to digit one for the low clock frequency. A functional diagram of the auto-range circuit is shown in Figure 3-5.

An overflow condition can exist if the selected number of counts to be counted in the input register do not occur within the time period required to fill the six counters of the period register. In this condition the displayed count rate will be in error. To warn the operator of this condition an *ERROR* legend will be displayed. Table 3-2 lists the overflow conditions.

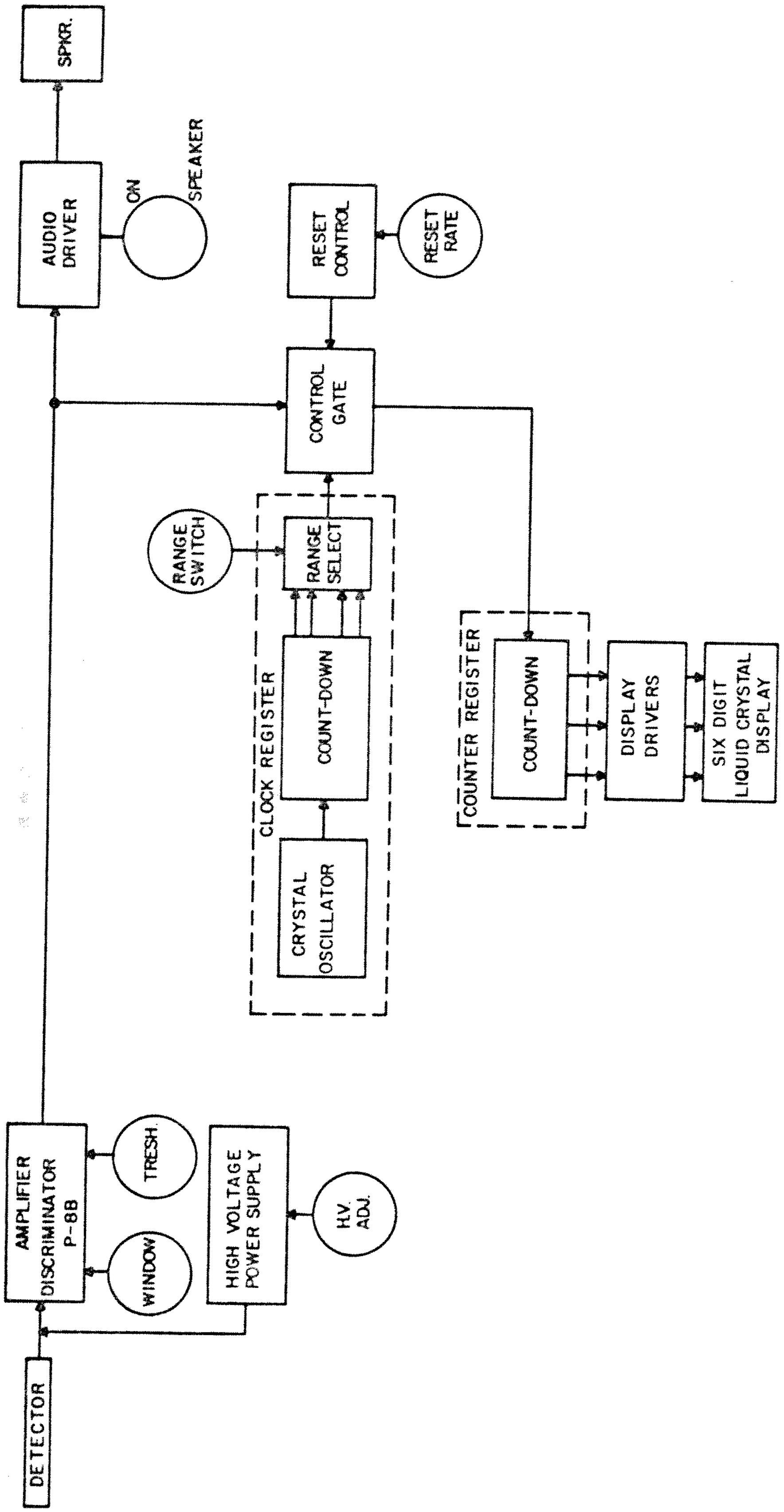


Figure 3-1. Scaler Functional Block Diagram (10763-C69)

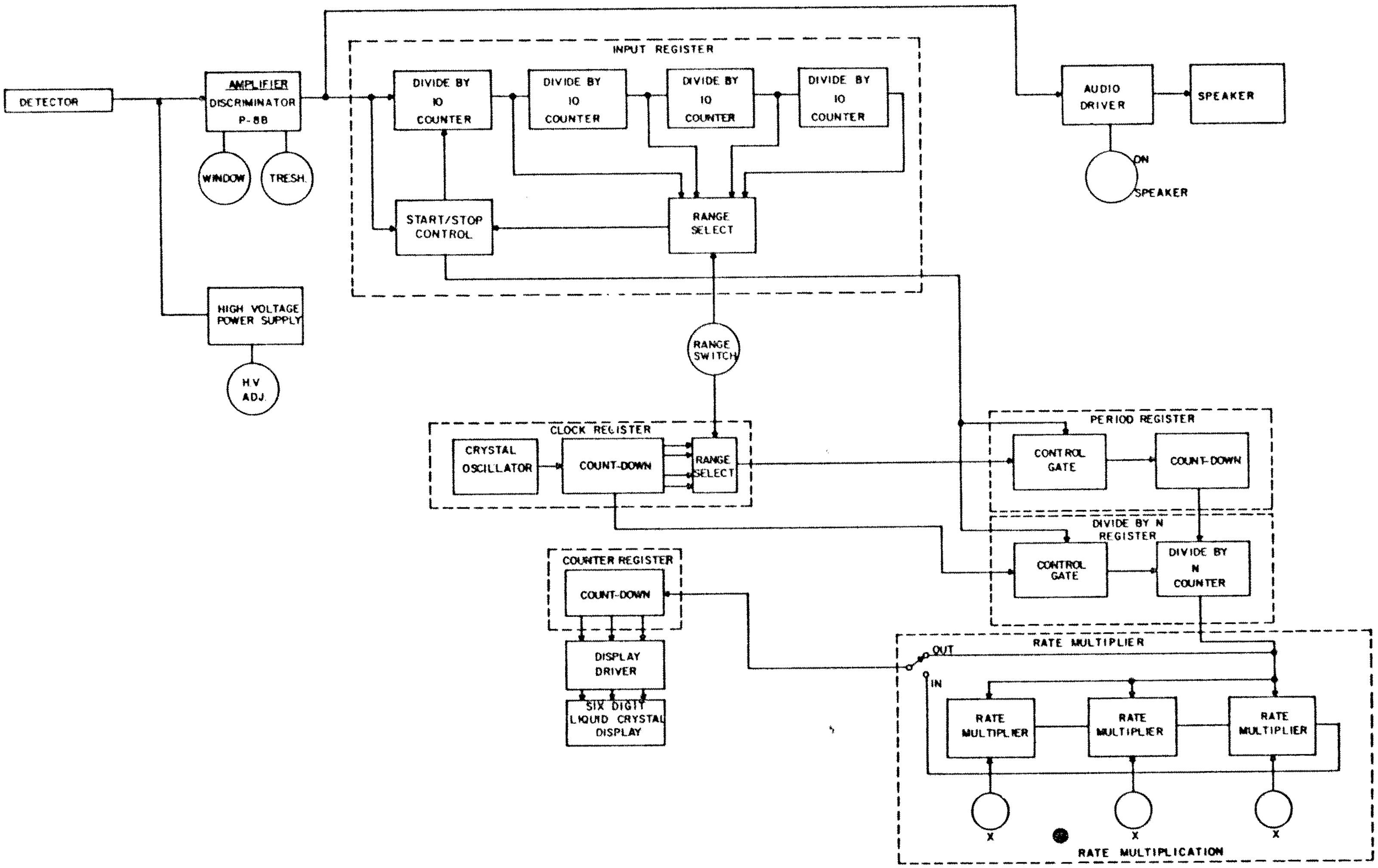


Figure 3-2. Ratemeter Functional Block Diagram with Rate Multiplier Calibration Board (10763-D70)

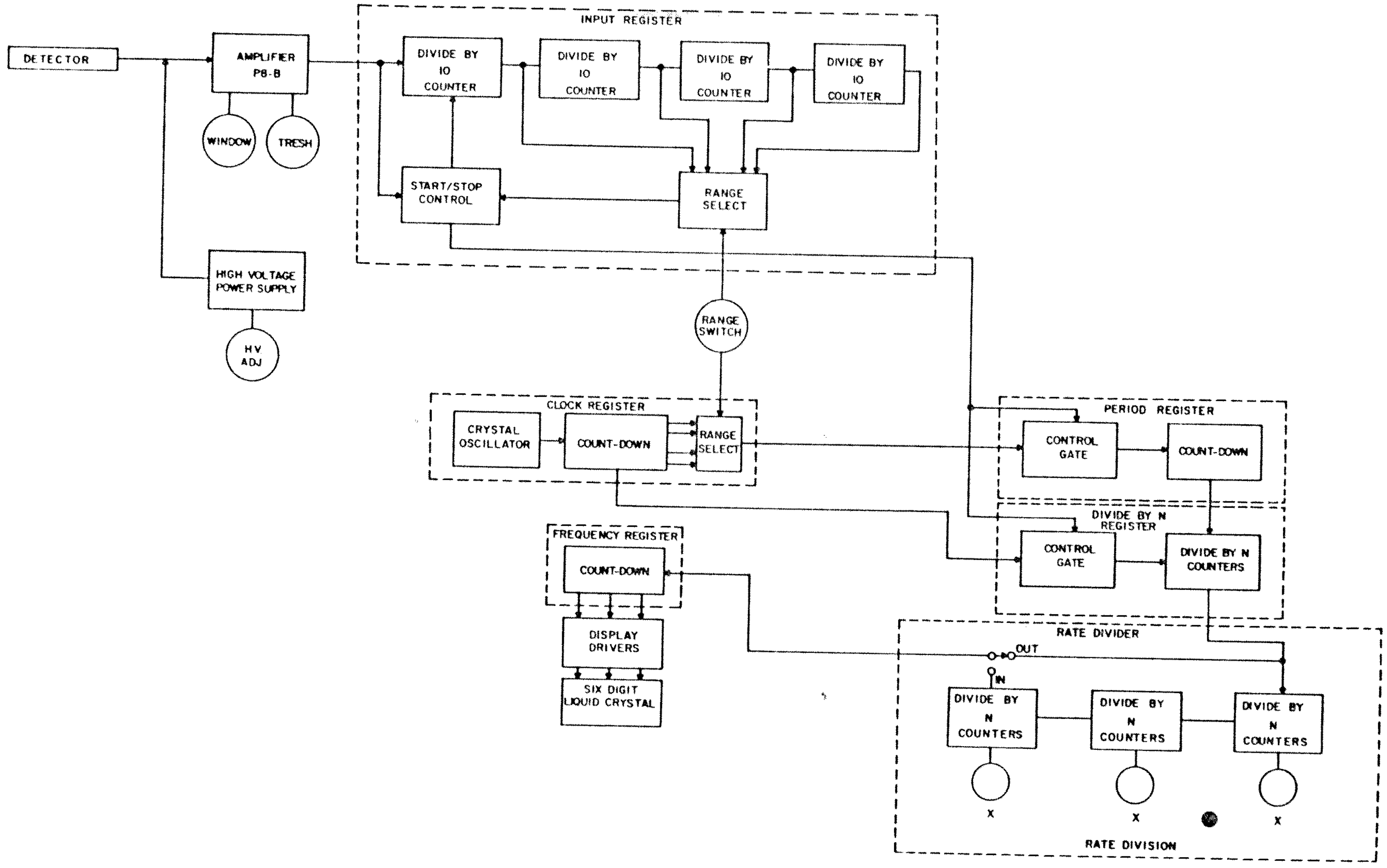


Figure 3-3. Ratemeter Functional Block Diagram with Rate Divider Calibration Board (10763-D71)

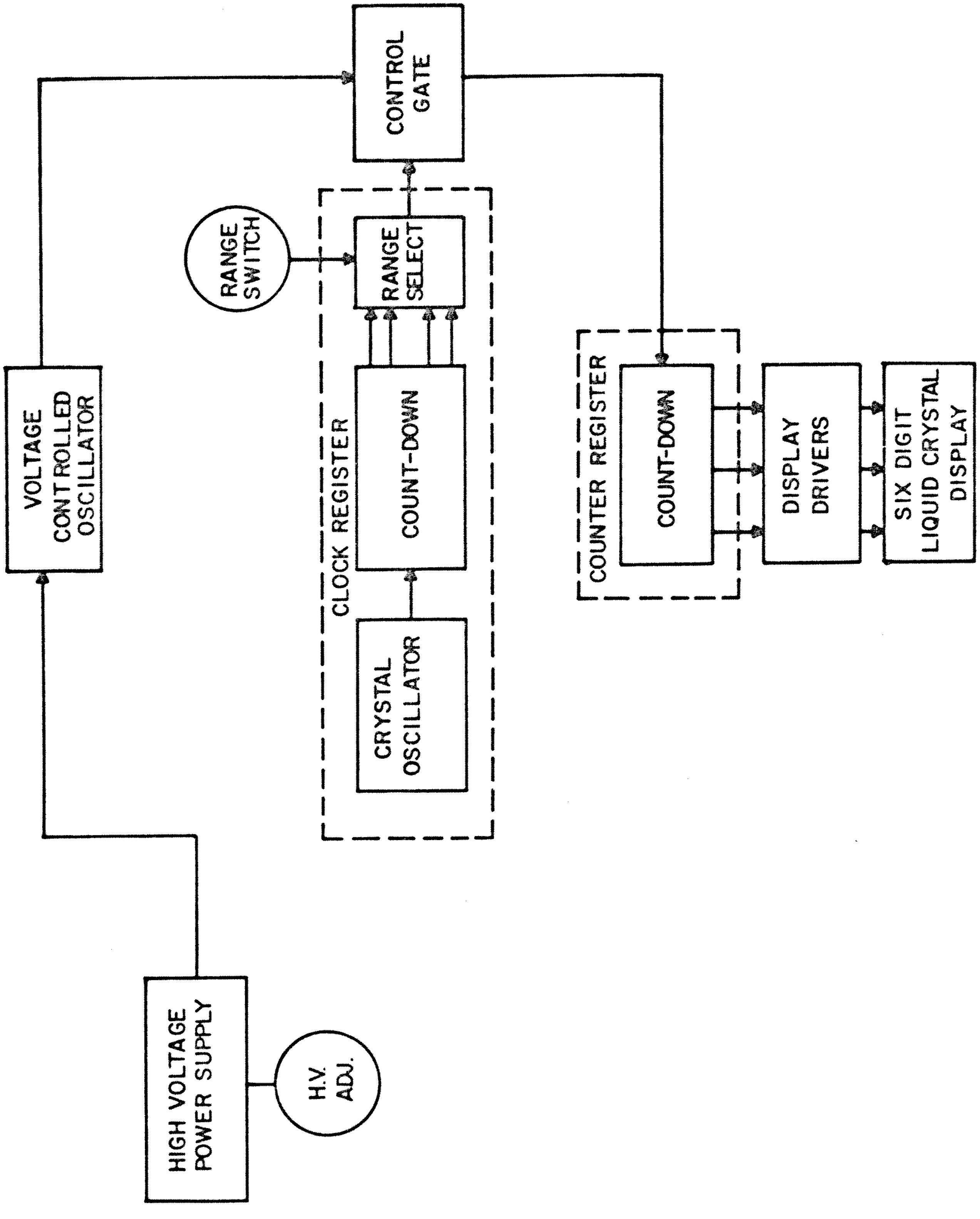


Figure 3-4. Voltmeter Functional Block Diagram (10763-C72)

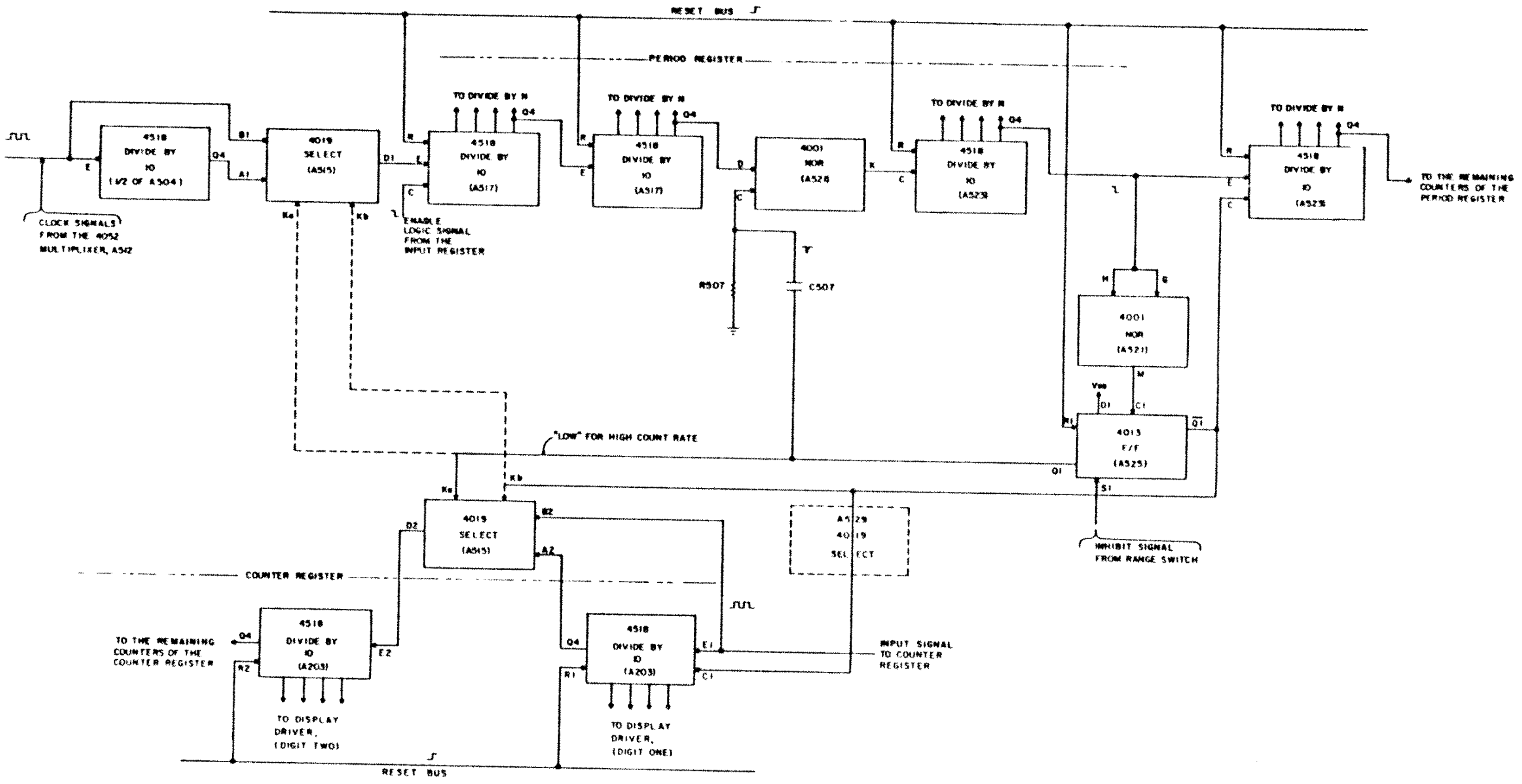


Figure 3-5. *Auto Range Functional Diagram (10763-D73)*

SWITCH POSITION	INPUT REGISTER COUNTS	INPUT TO MULTIPLEXER A512 PIN 10 (A)	Pin 9 (B)	SELECTED CLOCK FREQUENCY
A	10	LOW	LOW	10^5 Hz
B	100	HIGH	LOW	10^4 Hz
C	1,000	LOW	HIGH	10^3 Hz
D	10,000	HIGH	HIGH	10^2 Hz

Table 3-1. Range Switch — Ratemeter Logic

SWITCH POSITION	TIME REQUIRED FOR OVERFLOW TO OCCUR
A	1.67 minutes
B	16.7 minutes
C	167 minutes (2.78 hours)
D	1670 minutes (27.8 hours)

Table 3-2. Range Switch — Error Time Limits

To provide an error signal to indicate an overflow condition, the second section of flip-flop A525 is clocked by an inverter connected to the Q4 terminal of the last counter in the register. The flip-flop is latched when the last counter is full and is reset when the reset switch is closed. This flip-flop is also used to provide an *ERROR* indication for low battery conditions by a set signal from the battery condition circuitry. The selection of clock frequency is accomplished in multiplexer A512 and is a function of the range switch. See Table 3-1 for the clock frequency and range switch position.

6. Divide-By-N Register

The purpose of the divide-by-N register is to convert the period information, supplied by the period register, into frequency (or counts per minute) information and supply that information through the calibration function circuitry to the counter register. The conversion is accomplished by dividing a constant by the time period information in the period register.

Six divide-by-N counters (A516, A520, A522, A524, A526 and A528) are connected as a six-stage programmable frequency divider, with the master reset lines in parallel for both the counter reset and the counter enable function. The BCD period information from the respective decade counter in the period register is used to program the divide-by-N counters. The constant that is divided is a 6×10^6-bit signal (3 seconds of a 2×10^6-Hz clock signal).

A 2×10^6-Hz clock is supplied to the input of the first divide-by-N counter. The master reset line for the divide-by-N counters is controlled by the second section of dual flip-flop A507. The trailing edge of the negative enable signal from the input register sets the flip-flop, enabling the divide-by-N counters, and resets the clock register. Three seconds later a clock signal toggles the flip-flop, thus inhibiting and resetting the divide-by-N register and producing a reset signal for the input register and the period register. The master reset line for the divide-by-N register also provides a signal for the "compute" legend and an unblanking signal for the display drivers.

7. Calibration Function

The calibration function circuitry is used to convert the counts-per-minute rate from the divide-by-N register into other units, such as mR/h, and supply that information to the counter register. Two calibration function circuits, on individual plug-in boards, are available for this instrument: a rate multiplier and a rate divider. The function may be identified by the word *MULTIPLY* on the rate multiplier plug-in board and the word *DIVIDE* on the rate divider plug-in board. Both boards have an *IN-OUT* switch that activates the function in the *IN* position and bypasses the function in the *OUT* position. An additional switch on the board is used for scaler display and is not part of the calibration function. Both circuits are similar in construction and operation.

Common to both the multiplier and divider is the input circuitry. A quad two-input NOR gate and a dual flip-flop are connected to produce a 10-to-1 multiplication of the frequency supplied by the divide-by-N register. The signal from the divide-by-N register toggles the first section of a dual flip-flop to produce a high on the data (*D*) line of the second section flip-flop. A 10^5-Hz clock signal toggles the second section flip-flop, resetting the first flip-flop and providing a signal to a two-input NOR gate equal in width to one complete cycle of the 10^5-Hz signal. The other input to the NOR gate is a 10^6-Hz clock signal. The output of the NOR gate will then be a burst of 10 cycles, of the 10^6-Hz clock signal, at the rate of the signal supplied by the divide-by-N register.

The rate multiplier plug-in board has three digital rate multiplier (DRM) integrated circuits (A703, A704 and A705) connected in cascade and programmed by individual switches mounted on the board. By using the 10-to-1 multiplication input circuitry the total range of the rate multiplier is 0.01 to 9.99.

The rate divider plug-in board has three divide-by-N counters (A403, A404 and A405) connected as a three-stage programmable frequency divider. The counters are programmed by individual switches mounted on the board. Using the 10-to-1 multiplication input circuitry, the total range of the rate divider is 99.9 to 00.1.

8. Select Gate

The quad two-input select gate A529 is used to steer logic signals to the counter register and the display drivers for scaler and ratemeter functions. Diodes CR516 through CR518 form an OR gate to drive the select gate for the ratemeter mode, and diodes CR510 through CR515 form an OR gate to drive the select gate for the scaler mode.

In the ratemeter mode, the select gate routes the logic signals from the calibration board to the counter register, the inhibit signal from the auto range to the counter register inhibit, the unblanking signal from the divide-by-N register to the blanking input of the display drivers, and the "count" signal from the input register to the "count" display driver.

In the scaler mode, the select gate routes the logic signals from the P8-B amplifier (through NOR gate A508) to the counter register, the inhibit signal from flip-flop A507 to the inhibit of the counter register, the unblanking signal from the scaler switch on the calibration board to the blanking input of the display drivers, and the "count" signal from flip-flop A507 to the "count" display driver.

9. Scaler Function

The purpose of the scaler function is to count the detector input events for the period of time selected by the front panel range switch and to display the total count.

Output signals from the P-8B are supplied through NOR gate A508 and select gate A529 to the counter register. The timing signals from the clock generator are selected by multiplexer A519 and range switch position. Selected timing signals are supplied to the clock input of one section of dual flip-flop A507 through NOR gate A506. The flip-flop provides a gating signal to the counter register and a "count" legend signal through sections of select gate A525. The reset signal resets the clock register and the flip-flop. When the range switch is in the *MAN* or *STOP* positions, the flip-flop is held in the reset or set conditions, respectively.

At the completion of a timed count or when the range switch is placed in the *STOP* position, an unblanking signal is generated. If the *SCALER* switch is in the *STORE* position, the information in the counter register will update the count information latched in the display drivers and the data will be displayed. If the switch is in the *INCR* position the counter register will update the display drivers continuously.

10. High Voltage Voltmeter

The high voltage voltmeter uses the voltage controlled oscillator (VCO) section of a CD4046 (A518) as a voltage-to-frequency converter. The frequency is a nominal 10 kHz and is gated into the counter register for 0.1 seconds to give a digital display proportional to the high voltage. A voltage divider (R309 and R310) is used to reduce the high voltage to a value that can be used by the VCO. Capacitor C509 and the combined value of R514 and R515 set the nominal frequency, and R516 provides for a VCO offset adjustment. The range switch, when the the *HV* position, provides power for the VCO and the logic signals for the selection of clock frequency and steering logic. An inhibit signal is also supplied to NOR gate A508 to block signals from the P-8B amplifier.

11. Counter Register

Three dual-decade counters (A201, A202 and A203) are connected in cascade to provide a six-decade counter register. The input and inhibit signals to the first counter are supplied by the select gate A529, and the input to the second counter is supplied by the select gate A515. The six registers are reset by a common reset signal, and the six BCD output signals are supplied to corresponding liquid crystal drivers.

12. Display Driver

Six liquid crystal display drivers (A207 through A212) are used to drive the six, seven-segment, numerical digits of the liquid crystal display. The unblanking signal is provided to all six drivers from select gate A529. The ac drive signal is supplied by one section of the Quad EX-OR gate A205 which acts as a buffer amplifier for the 100 Hz clock signal.

The nine legends and three decimal points are driven by the EX-OR gates A204 through A206. One input of the gate is driven by the 100 Hz clock signal and the other gate is driven by the respective logic signal. Five legends and three decimal points are selected by switches on the display board. The remaining four legends are controlled by internal logic signals.

13. Display

The display in this instrument is a liquid crystal display with six seven-segment digits, three decimal points and nine legends. The display is powered by the liquid crystal drivers in the form of a 100 Hz square wave. When a segment, a decimal point, or legend is displayed, the phase of the signal will be out of phase with the display back plane. When the legend, decimal point, or segment is not displayed, the signal will be in phase with the back plane of the display.

The decimal points and five of the legends on the display are controlled by the legend switch on the display board. All other legends and the six digits are controlled by the logic within the instrument.

14. Reset Function

The *RESET* switch, SW603, resets all registers and circuits that have a reset capability, in either the scaler mode or the ratemeter mode of operation. A quad two-input OR gate (A514) is used to steer sequential reset logic and the simultaneous reset logic of the "reset" switch.

The "reset rate" control (R605 and SW606) resets all registers and circuits in the scaler mode only. One section of dual monostable multivibrator A302 is used to generate the reset signal. The multivibrator is triggered at completion of the scaler time period and generates a reset signal at the completion of the monostable period. Control R605 adjusts the RC time constant and switch SW606 enables the multivibrator.

15. Audio Driver

The audio driver circuitry drives a front panel mounted speaker SK601 to provide an audible indication of detector counts. The driver is controlled by the *SPKR ON* switch SW605.

To provide the necessary audible signal, the speaker is driven by a burst (approximately five cycles) of a 2 kHz clock signal at the rate the detector counts are received by the instrument. The speaker drive is supplied by audio amplifier A301. The audio amplifier requires two input signals; one is the 2 kHz clock signal and the other is a pulse of approximately 2.5 milliseconds (ms) duration supplied by one section of a dual monostable multivibrator A302. The multivibrator is triggered by a signal from the P-8B amplifier.

16. Battery Condition Indicator

The battery condition circuitry provides a signal to display the *BATT OK* legend when the battery voltage is above a set point and provides a signal for *ERROR* display when the battery voltage is below the set point.

Resistors R520 and R521 and constant-current diode CR520 form a fixed voltage source that is supplied to the input of an inverter connected NOR gate A508. When the V_{DD} supply voltage of the NOR gate is reduced to the trip threshold, the NOR gate output will change state. Resistor R520 is adjusted for the trip point.

The logic signal for the *BATT OK* legend is supplied to the display driver. The logic signal for the *ERROR* legend is supplied through an inverter connected NOR gate A521 to set the second section of dual flip-flop A525.

17. Battery Power

Three battery power systems are available for this instrument: a primary battery pack, a Ni-Cd rechargeable battery pack, and a Gel-Cell rechargeable battery. The primary battery pack has provisions for five 1.5 V D-cell primary batteries such as C-Zn alkaline, etc. The Ni-Cd battery pack uses five 1.25 V D-cell batteries and may be recharged. The Gel-Cell battry is a single battery providing 6 V and may also be recharged. Both rechargeable battery systems may be recharged, using the proper battery charger, while in the instrument, but no attempt should be made to recharge the primary battery system.

SECTION IV
MAINTENANCE

A. ASSEMBLY AND REASSEMBLY

1. To remove the case, place the range switch in the *OFF* position, then release the catches at each end of the instrument.

CAUTION

> The high voltage power supply in this instrument produces voltages that can cause a severe electrical shock. Use caution when working on the instrument. If the high voltage power supply is not required while working on the instrument, it is advisable to remove the supply and short out C601.

2. Printed Circuit Board Removal

a. High Voltage Power Supply: Remove one 4-40 screw on front of chassis, opposite the supply, and unplug the power supply.

b. P-8B Amplifier-Discriminator: Remove one 4-40 screw on front of chassis, opposite the P-8B, and unplug the board.

c. Calibration Board: Remove one 4-40 screw on front of chassis, opposite the calibration board, and unplug the board.

d. Display Board, Main Board and Mother Board: Remove front cover by removing four front cover screws. Carefully separate the front cover from the chassis and unplug the display board. Unplug the main board and the mother board. The display board may be removed by removing four 2-56 nuts. The main board may be removed by removing four 2-56 screws. The mother board may be removed by unsoldering the lead to C601 and the lead to C307 and removing six 4-40 screws.

3. To reassemble, reverse the above procedures.

B. CALIBRATION BOARDS AND PROGRAMMING

1. General: The calibration description in this subsection is for the calibration boards and their control switches. For adjustment of other internal controls refer to Section IV E. of this manual.

The function of the calibration board is to convert the counts per minute rate to a working rate, such as mR/h, and display that value. The calibration function operates in the ratemeter mode only.

Two calibration boards are available for the instrument — a rate multiplier board and a rate divider board. The board supplied with the instrument is determined by instrument application and the detector used. The board type may be identified by the legend on the front of the board, with *DIVIDE* indicating a rate divider board and *MULTIPLY* indicating a rate multiplier board.

For the calibration function to operate, the *CALIB* switch on the board must be in the *IN* position and the function switch on the front panel must be in the *RATE* mode.

The *SCALER* switch on the board is for the scaler function only and is not part of the calibration function. Refer to Section IV B.5.

2. Rate Multiplier Board: The three selector switches on the board provide a multiplication range of 9.99 to 0.01. By use of the decimal points available on the liquid crystal display, the total range may be extended to 0.00001.

For example: If a probe used with the instrument is 53 percent efficient and a cpm display is desired, then using the reciprocal of 53 percent, or 1.89, as a multiplier, the selector switches are adjusted to 1.89 and the resulting reading will be in cpm. If a G-M tube detector with a conversion factor of 1500 cpm per mR/h is used and a display in mR/h is desired, then using the reciprocal of 1500, or 0.00067, as a multiplier, the selector switches are adjusted to 0.67 and the third decimal point (DP 3) is activated. The display will now indicate mR/h.

3. Rate Divider Board: The three selector switches on the board provide a division range of 99.9 to 00.1. By use of the decimal points available on the liquid crystal display the total range may be extended to 99,900.

For example: If a G-M tube detector with a conversion factor of 1500 cpm per mR/h is used and a display in mR/h is desired, then using 1500 as a divisor, the selector switches are adjusted to 15.0 and the second decimal point (DP 2) is activated. The display will now indicate mR/h.

4. Programming

The legends: "counts per second", "R/h", "mR/h", "cpm" and "mrem/h" may be displayed on the liquid crystal display in the ratemeter mode of operation. The legends are controlled by the internal legend switches (display board). The legends are not

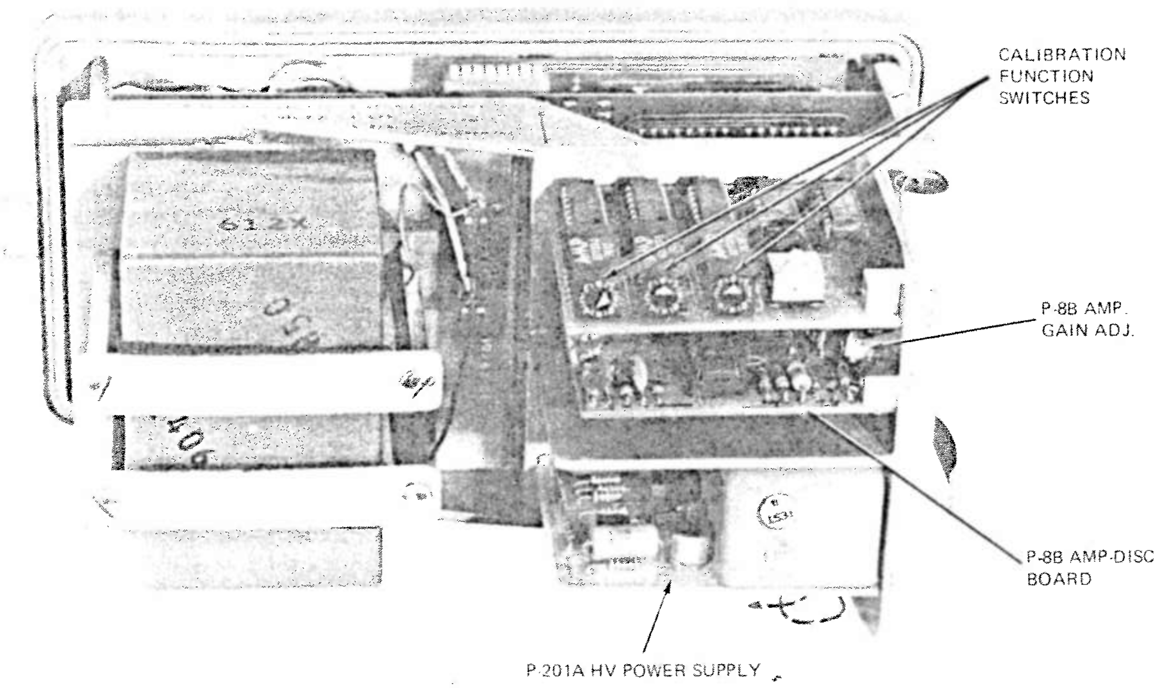


Figure 4-1. Interior View

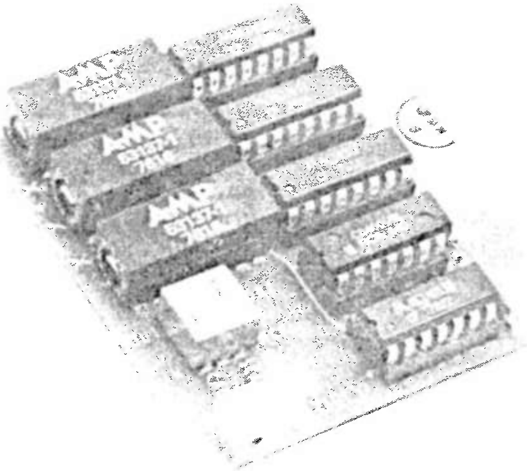


Figure 4-2. Rate Multiplier Board

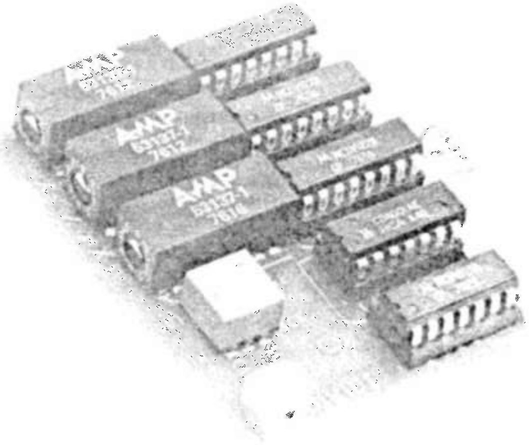


Figure 4-3. Rate Divider Board

controlled by the internal *CALIB IN-OUT* switch (calibration board). The legend switches control only the legends on the display and do not control the function of the instrument.

As in the previous example, using a G-M tube with a conversion of approximately 1500 cpm per mR/h, the calibration board is adjusted to provide a readout in mR/h. The legend switches are then programmed to display mR/h by selecting and closing (on) switch 6.

5. Scaler: The *SCALER* switch on the calibration board provides a choice of readout for the scaler function. In the *STORE* position the counts are stored and the display readout is updated at the completion of the timed cycle or when the range switch is placed in the *STOP* position. In the increment position the display is updated with each count.

C. PREVENTIVE MAINTENANCE

The instrument is splashproof; however, it should be kept as clean and dry as possible.

Avoid prolonged periods of exposure at extreme temperatures to prevent shortened battery life.

If recharged batteries are supplied with the instrument, recharge the batteries when they become discharged. Do not store the instrument with discharged batteries. If the instrument is to be inactive for a long period of time, it is advisable to remove the batteries.

D. BATTERY CHARGING

Recharge the batteries for 10 to 16 hours for a discharged battery. Less time will be required for a partially discharged battery. Charging the batteries for up to two days is permissible but it is not advised.

CAUTION

Do not over-charge the batteries. Damage to the equipment could occur if the batteries are over-charged.

Do not attempt to recharge the batteries with a charger that is not designed to be used with the batteries installed in the instrument.

Do not attempt to recharge primary batteries that are not designed to be recharged.

Disconnect the battery charger from the power main when not in use.

E. ADJUSTMENTS—INTERNAL CONTROLS

1. *BATT OK:* Place the range switch in the *OFF* position, and remove the battery pack or adapter. Connect a well regulated power supply, capable of supplying an adjustable voltage between 5 V and 7 V at 150 mA, to the battery connector on the chassis. OBSERVE CORRECT POLARITY — the positive terminal is the one nearest the front of the chassis.

Adjust the power supply for 5.75 V and turn the range switch to position A; the *BATT OK* legend should indicate. Adjust the power supply to 5.60 V; the *BATT OK* legend should not indicate and the *ERROR* legend should indicate. Adjust *BATT OK ADJ* potentiometer R520, if necessary, to give the above indications.

2. VCO Frequency and VCO Offset: Connect an electrostatic voltmeter to C601 and place the range switch in the *HV* position.

CAUTION

The voltages produced by the high voltage power supply can cause a severe electrical shock. Use caution when working on the instrument.

Adjust the *HV ADJ* (front panel) for 1500 V. If the display does not indicate 1500 V ±5 percent, adjust the VCO frequency (R515) potentiometer. Adjust the *HV ADJ* to 500 V. If the display does not indicate 500 ±5 percent, adjust the *VCO OFFSET* (R516) potentiometer. These adjustments are interactive and several adjustments may be necessary for complete adjustment.

NOTE

The range of the VCO may be changed, if desired, by adding a resistor in parallel with R310.

The VCO has a range ratio of approximately 3 to 1. See Table 4-1 for ranges and value of R310.

VCO RANGE	R310
500 V to 1500 V	2.7 MΩ (STD.)
800 V to 2400 V	4.32 MΩ in parallel with 2.7 MΩ

Table 4-1. Voltmeter Range

3. *P-8B Gain Adjust:* The P-8B gain is normally adjusted for a gain of 10 with reference to signal input

to the instrument and signal at the input to the comparator, pin 4 of A1. The gain may be adjusted between approximately 8 and 12 by use of capacitor C4.

F. TROUBLESHOOTING

The use of the schematic diagrams, along with the "Theory of Operation" section and its functional diagrams, should help isolate and locate problems.

Most of the circuitry is CMOS integrated circuits. It is advisable, when troubleshooting, to use instruments that have a high input impedance so as not to disturb the circuits. Use care not to introduce static charges, as CMOS circuits are sensitive and may be damaged.

For high voltage measurements it is advisable to use an electrostatic voltmeter or other instrument with an extremely high impedance.

CAUTION

> The high voltage power supply in the instrument produces voltages that can cause a severe electrical shock. Use caution when measuring high voltage or working on the high voltage power system.

SECTION V
PARTS LIST

The following table lists the electronic items incorporated in the PRS-1/PRS-2 and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only. There are no restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
1. P-8B-Amplifier/Discriminator Board				
A1	Integrated Circuit	Quad Comparator	National LM339N or equivalent	ICACA0339N
A2	Integrated Circuit	Dual Type D Flip-Flop	RCA CD4013BE or equivalent	ICCMA4013B
A3	Integrated Circuit	Quad, Two-Input NOR	RCA CD4001BE or equivalent	ICCMA4001B
C1	Capacitor	360 μF, 15 V	GE69F222162 or equivalent	CPTA361M4H
C2	Capacitor	3.3 μF, 15 V	CS13	CPTA335P3H
C3	Capacitor	0.001 μF, 200 V	Sprague 192P-10292 or equivalent	CPPF102P3R
C4	Capacitor	Variable, 2.5 to 10 pF	E. F. Johnson 274-1009-005	CPVA1
C5	Capacitor	2.2 μF, 20 V, Tantalum	CS13	CPTA225P3I
C6	Capacitor	220 pF, Disc Ceramic		CPCE221P3U
C7	Capacitor	100 pF, Disc Ceramic		CPCE101P3U
C8	Capacitor	330 pF, Ceramic		CPCE331P3P
CR1	Diode	Constant Current	1N5289	CRZR1N5289
CR2, CR3	Diode		1N4148	CRSI1N4148
Q1	Transistor	Field Effect	2N5358	TRJN2N5358
Q2	Transistor	NPN	2N4124	TRSN2N4124
R1	Resistor	100, 1/4 W, 5%		RECC101B22
R2	Resistor	1k, 1/4 W, 5%		RECC102B22
R3	Resistor	2.4k, 1/4 W, 5%		RECC242B22
R4	Resistor	5.6M, 1/8 W, 5%		RECC565B22
R5	Resistor	22k, 1/4 W, 5%		RECC223B22
R6	Resistor	27k, 1/4 W, 5%		RECC273B22
R7, R8	Resistor	4.7k, 1/4 W, 5%		RECC472B22
R9, R11	Resistor	10k, 1/4 W, 5%		RECC103B22
R10	Resistor	6.8k, 1/4 W, 5%		RECC682B22
R12	Resistor	2.2k, 1/4 W, 5%		RECC222B22
R13	Resistor	20k, 1/4 W, 5%		RECC203B22

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
2. Display Board				
A201, A202, A203	Integrated Circuit	Dual BCD Counter	RCA CD4518BE or equivalent	ICCMA4518B
A204, A205, A206	Integrated Circuit	Quad, Two-Input EX-OR	RCA CD4030BE or equivalent	ICCMA4030B
A207, A208, A209, A210, A211, A212	Integrated Circuit	Driver, Liquid Crystal Display	Motorola MC14543BCP or equivalent	ICCMA4543B
DSP201	Display	Liquid Crystal Display		ZP10763002
R201, R202, R203, R204, R205	Resistor	100k, 1/8 W, 5%		RECC104B21
R206, R207, R208	Resistor	51k, 1/8 W, 5%		RECC513B21
SW201	Switch	8 Station, SPST	Grayhill 76B08	SWMI5
3. Mother Board				
A301	Integrated Circuit	Audio Amplifier	National LM380N-8	ICAAA00380
A302	Integrated Circuit	Dual Monostable Multivibrator	Motorola MC14528CP	ICCMA4528A
C301, C309, C310	Capacitor	0.1 μF, 12 V, Disc Ceramic		CPCE104P3G
C302, C305	Capacitor	0.01 μF, 50 V, Disc Ceramic		CPCE103P3N
C303	Capacitor	820 pF, 100 V, Ceramic	AVX CK12BX821 M	CPCE821P3P
C304	Capacitor	15 μF, 10 V, Tantalum	CS13 Case A	CPTA150M3F
C306	Capacitor	120 μF, 10 V, Tantalum	CS13 Case D	CPTA121M3F
C307	Capacitor	220 pF, 3 kV, Ceramic		CPCE221P3Y
C308	Capacitor	0.001 μF, 200 V, Paper		CPPF1023R
CR301, CR302, CR303, CR304, CR306	Diode		1N4148	CRSI1N4148
CR305	Diode	Zener, 5.3 V, ±0.2 V		CRXX1
R301	Resistor	10k, 1/8 W, 5%		RECC103B21
R302	Resistor	1M, 1/8 W, 5%		RECC105B21
R303	Resistor	2.7, 1/8 W, 5%		RECC271N21
R304	Resistor	33k, 1/8 W, 5%		RECC333B21
R305, R307, R308	Resistor	100k, 1/8 W, 5%		RECC104B21
R306	Resistor	10k, 1/8 W, 10%		RECC103B21
R309, R310	Voltage Divider	1000M, 2.7M	Victoreen MOX-2RD	REXX2
R311	Resistor	220, 1/8 W, 5%		RECC221B21
R312	Resistor	10M, 1/8 W, 5%		RECC106B21

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
4. Calibration Board — Rate Divider				
A401	Integrated Circuit	Quad, Two-Input NOR	RCA CD4001BE or equivalent	ICCMA4001B
A402	Integrated Circuit	Dual Type D Flip-Flop	RCA CD4013BE or equivalent	ICCMA4013B
A403, A404, A405	Integrated Circuit	Divide-by-N	Motorola MC14522BCP or equivalent	ICCMA4522B
C401	Capacitor	820 pF, 100 V, Ceramic	AVX CK12BX821K	CPCE821P3P
R401	Resistor	100k, 1/8 W, 5%		RECC104B21
SW401	Switch	2-Station SPDT	Grayhill 76SC02	SWMI4
SW402, SW403, SW404	Switch	Decimal	AMP 53919-1	SWMI2 SWMI12
5. Calibration Board — Rate Multiplier				
A701	Integrated Circuit	Quad, Two-Input NOR	RCA CD4001BE or equivalent	ICCMA4001B
A702	Integrated Circuit	Dual Type D Flip-Flop	RCA CD4013BE or equivalent	ICCMA4013B
A703, A704, A705	Integrated Circuit	Rate Multiplier	Motorola MC14527BCP or equivalent	ICCMA4527B
C701	Capacitor	820 pF, 100 V, Ceramic	AVX CK12BX821K	CPCE821P3P
R701	Resistor	100k, 1/8 W, 5%		RECC104B21
SW701	Switch	2-Station SPDT	Grayhill 76SC02	SWMI4
SW702, SW703, SW704	Switch	Decimal	AMP53919-1	SWMI12
6. Main Board				
A501	Integrated Circuit	Quad, Two-Input NOR	RCA CD4001AE or RCA CD4001UBE, Unbuffered Only	ICCMA4001A
A506, A508, A521	Integrated Circuit	Quad, Two-Input NOR	RCA CD4001BE or equivalent	ICCMA4001B
A502, A503, A504, A509, A510, A513, A517, A523, A527	Integrated Circuit	Dual BCD Counter	RCA CD4518BE or equivalent	ICCMA4518B
A505	Integrated Circuit	Time Base Counter	Motorola MC14566BCP or equivalent	ICCMA4566B
A507, A511, A525	Integrated Circuit	Dual Type D Flip-Flop	RCA CD4013BE or equivalent	ICCMA4013B
A512	Integrated Circuit	Multiplexer	RCA CD4052BE or equivalent	ICCMA4052B

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
A514	Integrated Circuit	Quad Two-Input OR	RCA CD4071BE or equivalent	ICCMA4071B
A515, A529	Integrated Circuit	Quad AND/OR Select	RCA CD4019BE or equivalent	ICCMA4019B
A516	Integrated Circuit	Divide-by-N Counter	Motorola MC14522BL or equivalent	ICCME4522B
A518	Integrated Circuit	VCO	RCA CD4046AE, Unbuffered Only	ICCMA4046A
A519	Integrated Circuit	Multiplexer	RCA CD4051BE or equivalent	ICCMA4051B
A520, A522, A524, A526, A528	Integrated Circuit	Divide-by-N Counter	Motorola MC14522BCP or equivalent	ICCMA4522B
C501	Capacitor	18 pF, NPO, Ceramic	Erie ET05-000-COGO-180K	CPCE180P3P
C502, C510, C511	Capacitor	820 pF, 100 V, Ceramic	AVX CK12BX821K	CPCE821P3P
C503, C505, C512	Capacitor	68 pF, 100 V, Ceramic	AVX CK12BX680K	CPCE680P3P
C504, C506, C507	Capacitor	33 pF, 100 V, Ceramic	AVX CK 12BX330K	CPCE330P3P
C508	Capacitor	0.01 μF, 50 V, Disc Ceramic		CPCE103P3N
C509	Capacitor	0.001 μF, 50 V, Paper	MAPCO 71901AA102PK500AX	CPPF102P3N
CR501-CR519, CR521	Diode		1N4148	CRSI1N4148
CR520	Diode		1N5283	CRZR1N5283
R501, R524	Resistor	10M, 1/8 W, 10%		RECC106B21
R502	Resistor	15k, 1/8 W, 10%		RECC153B21
R503, R504, R505, R506, R507, R508, R509, R511, R512, R513, R517, R518, R519, R522, R523, R525, R526, R527, R528	Resistor	100k, 1/8 W, 10%		RECC104B21
R510	Resistor	2.7k, 1/8 W, 10%		RECC272B21
R514	Sensistor	10k, 1/8 W, 10%	Texas Instruments TG 1/8	RETS103BX1
R515	Potentiometer	100k, 1/4 W	Spectrol 62-2-1-104	PTCE104B23
R516	Potentiometer	1M, 1/4 W	Spectrol 62-2-1-105	PTCE105B03
R520	Potentiometer	50k, 1/4 W	Spectrol 62-2-1-503	PTCE503B03
R521	Resistor	5.1k, 1/8 W, 5%		RECC512B21
Y501	Crystal	2000 kHz, 0.0025% Tol. at 26 °C, HC 33/U Holder	International Crystal F-700 or equivalent	CYOS1

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
7. Cover				
C601	Capacitor	0.05 μF, 3500 V	CAPCO EBL-1	CPPF503PXY
C602	Capacitor	120 μF, 15 V		CPTA121M3H
J601	Jack	Battery Charger	Switchcraft 142A	COAF13
	Jack Cover		Switchcraft RC-5986	
L601	Lamp	5 V, 75 mA, T3/4	7133	LPLP5
R601	Resistor	33, 1/2 W		RECC330B23
	If a brighter light is desired on Ni-Cd or Gel-Cell batteries only, use a 16 Ω, 1/2 W resistor in place of R601.			
R602, R603	Potentiometer	10k, Ten-Turn (See Note)	Helipot 7276 R10K, L.25	PTWW103B05
R604	Potentiometer	25k	AB WA1MO28S253UW	PTCC253B03
R605	Potentiometer	1M with Switch	Mallory MLC-16LS	PTCC105B02
R606	Resistor	47, 1/4 W, 5% (See Note)		RECC470B22
R607	Resistor	390k, 1/4 W, 5%		RECC394B22
	NOTE: For PRS-2: R602 and R606 are not used, R603 is 1 kΩ; AB WA1M028S102UW			
SK601	Speaker	1-inch-diameter, 8 Ω		ADSP4
SW601	Switch	Range	Eberline 10763-C14	SWRO40
SW602	Switch	Pushbutton SPST	SAIRV2O Cutler-Hammer	SWPB4
SW603	Switch	Pushbutton SPDT	8121Y4ZE, C & K	SWPB14
SW604	Switch	Toggle, SPDT	C & K 7101	SWTO12
SW605	Switch	Toggle, DPDT	MTA206N Alco	SWTO3
8. P-201 A High Voltage Power Supply Board				
C101	Capacitor	0.1 μF, 10%, 80 V	Sprague 192P1049R8	CPPF104P3O
C102	Capacitor	3.3 μF, 10%, 15 V	Kemet K3R3C10	CPTA335P3H
C103	Capacitor	120 μF, 10%, 10 V	Kemet K120C10	CPTA121M3F
CR101	Diode	2500 PIV	Varo VA-25	CRSIVA0025
CR102	Diode		1N34A	CRGE1N0034
CR103	Diode		Motorola MZ2361	CRZRMZ2361
Q101	Transistor		2N4234	TRSP2N4234
Q102, Q106	Transistor		Motorola 2N4124	TRSN2N4124
Q103	Transistor		Motorola 2N4126	TRSP2N4126
Q104, Q105	Transistor	Matched pair, FET		TRXX1

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
8. P-201A High Voltage Power Supply Board (continued)				
R101	Resistor	470, 1/4 W, 5%		RECC471B22
R102	Resistor	3.3k, 1/4 W, 5%		RECC332B22
R103	Resistor	1.2k, 1/4 W, 5%		RECC122B22
R104	Resistor	680, 1/4 W, 5%		RECC681B22
R105	Resistor	3.9k, 1/4 W, 5%		RECC392B22
R106, R107, R108	Resistor	22M, 1/4 W, 5%		RECC226B22
R109	Resistor	160k, 1/4 W, 5%		RECC164B22
R110	Resistor	2.2M, 1/4 W, 5%		RECC225B22
R111	Resistor	68k, 1/4 W, 5%		RECC683B22
R112	Resistor	10M, 1/4 W, 5%		RECC106B22
R113	Resistor	10k, 1/4 W, 5%		RECC103B22
R114	Resistor	33k, 1/4 W, 5%		RECC333B22
R115	Resistor	22M, 1/8 W, 5%		RECC226B21
T101	Transformer Assembly		Eberline 10931-00	YP10931000
9. Battery Pack				
BT801	Battery	Gel-Cell Lead-Acid 6 V 1.8 AH	Globe GC620 Type B	BTGC4
CR801	Diode	Zener	1N5342B	CRZR1N5342
	Battery Charger	Charger for Gel-Cell battery only	10763-A46	ZP10763046
Items listed below are components for optional power sources.				
BT601-BT605	Battery	C-Zn, "D" cells (these batteries are used in the BP-1-1)	NEDA 30 or equivalent	BTCZ3
BT601-BT605	Battery	Ni-Cd, "D" cells (these batteries are used in the BP-1-4)	Eveready CH4 or equivalent	BTNC1
	Battery Charger	Charger for Ni-Cd batteries, "D" cells only	Eberline 10763-A23	ZP10763023

SECTION VI
DIAGRAMS

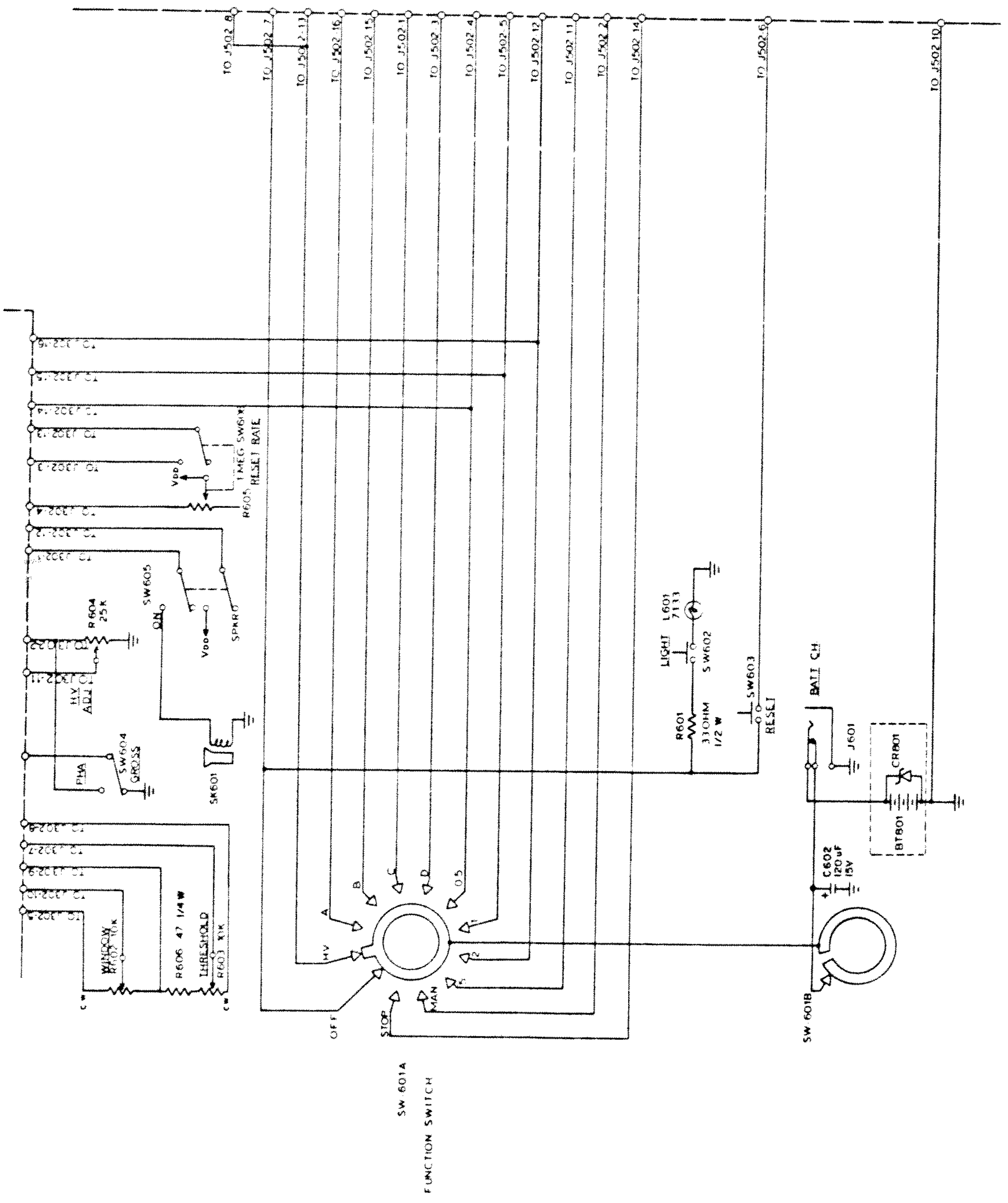


Figure 6-1. Front Panel Schematic, Model PRS-1 (10763-D74)

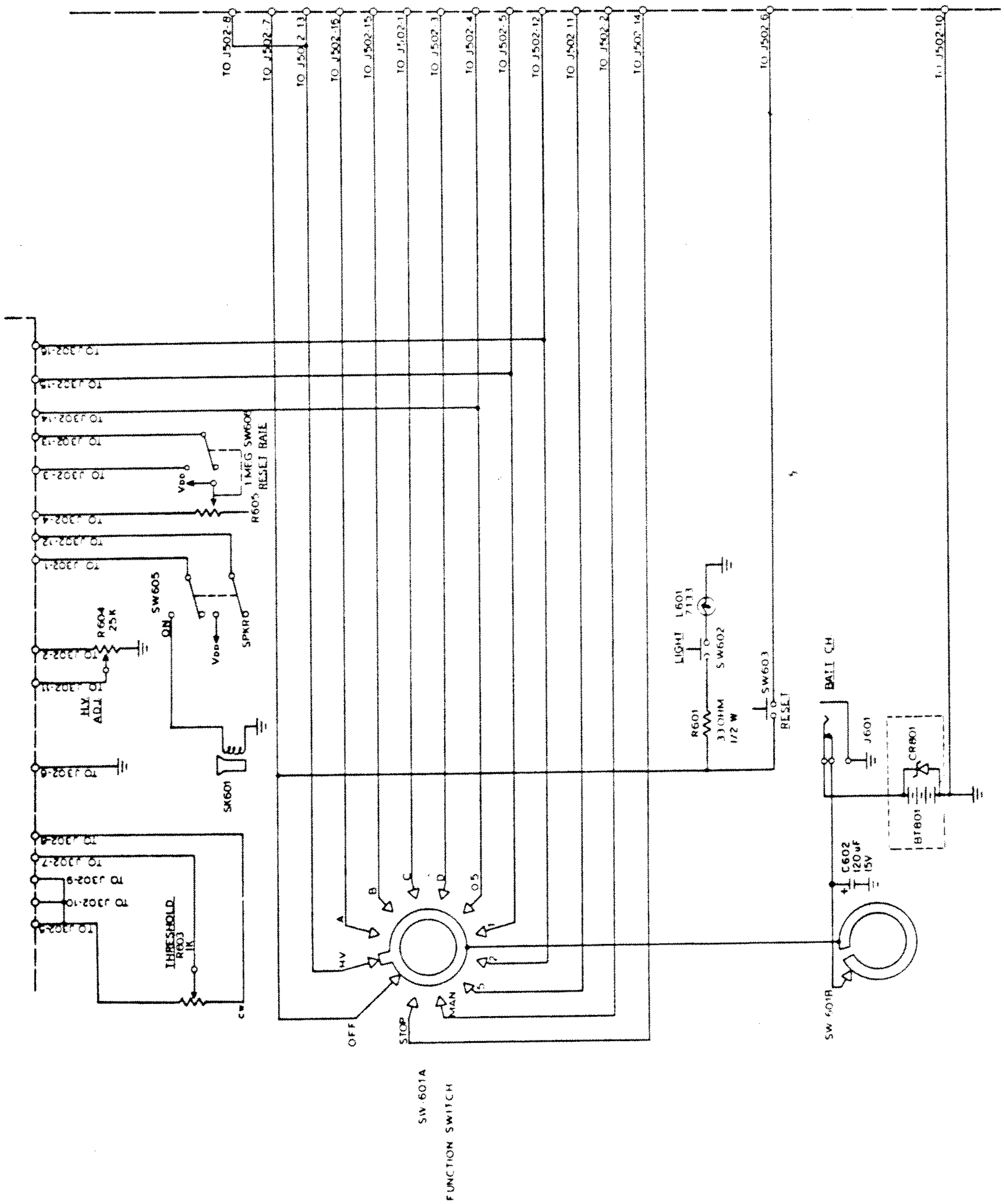
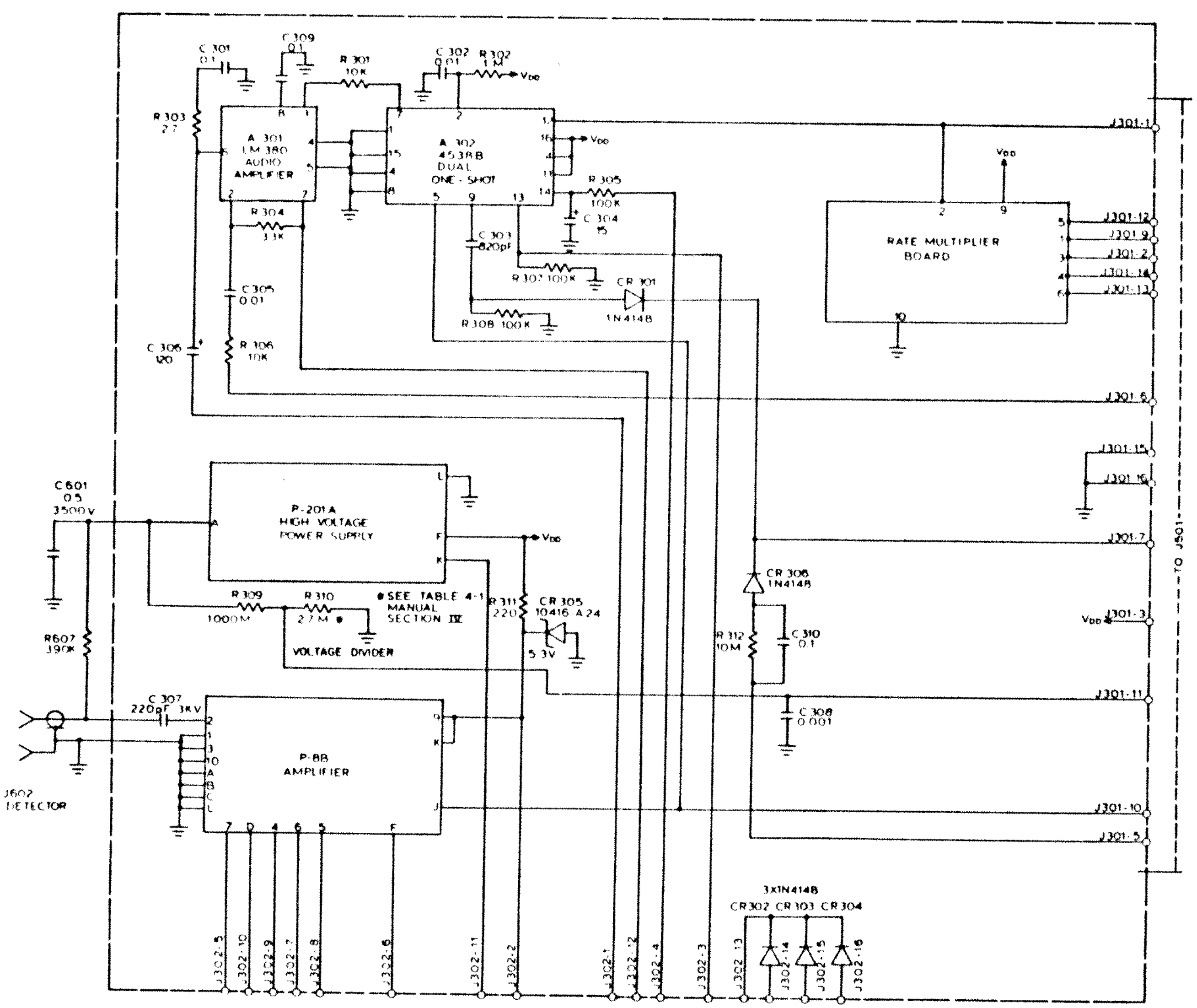


Figure 6-2. Front Panel Schematic, Model PRS-2 (10763-D75)



NOTE:

R310 value may be changed by adding a 4.32 Ω resistor in parallel with the 2.7 MΩ resistor to provide a high range of high voltage. Refer to Section VI E.2. for more information.

Figure 6-3. Mother Board Schematic (10763-D67B)

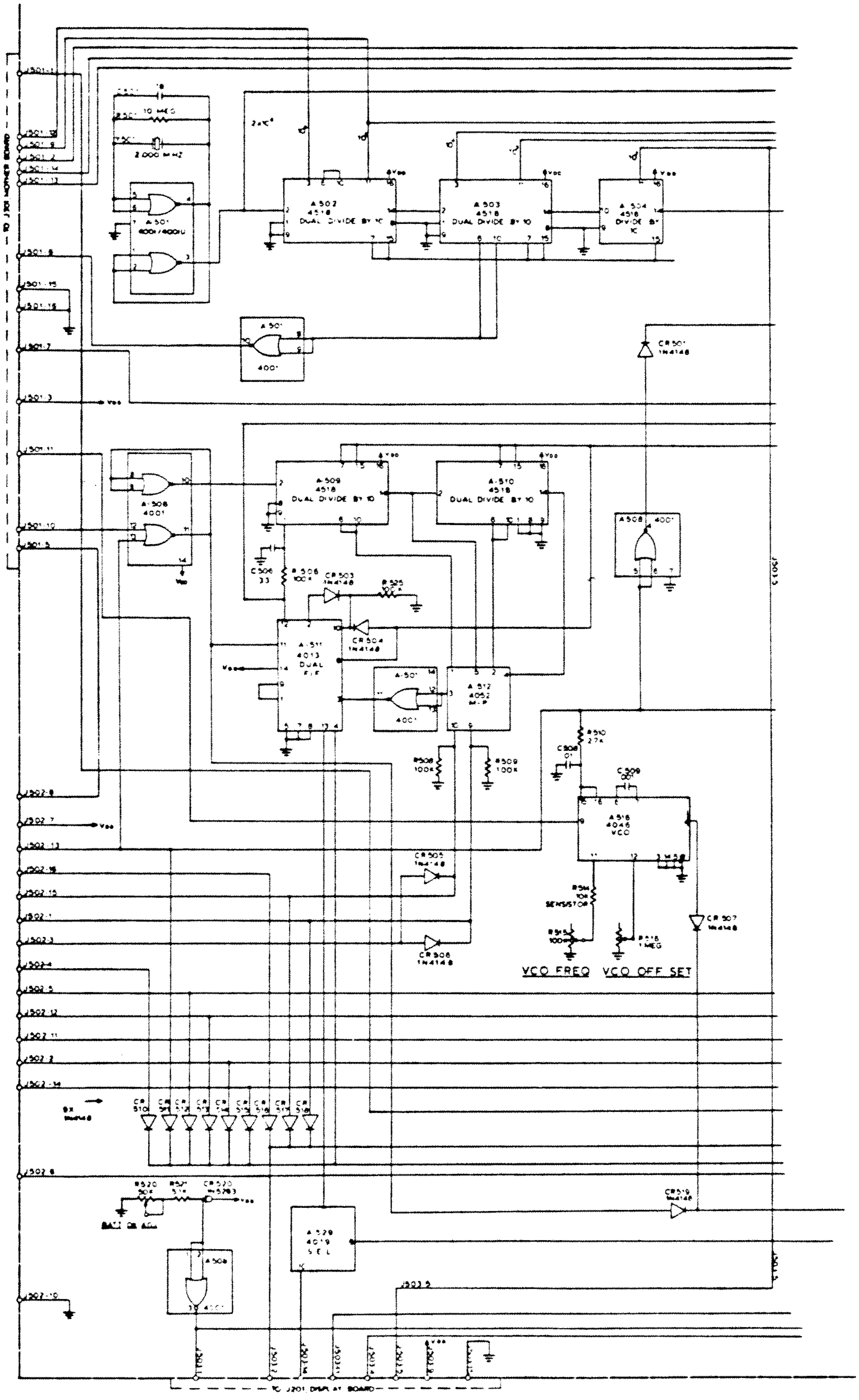


Figure 6-4. Main Board Schematic, Sheet 1 of 2 (10763-D76)

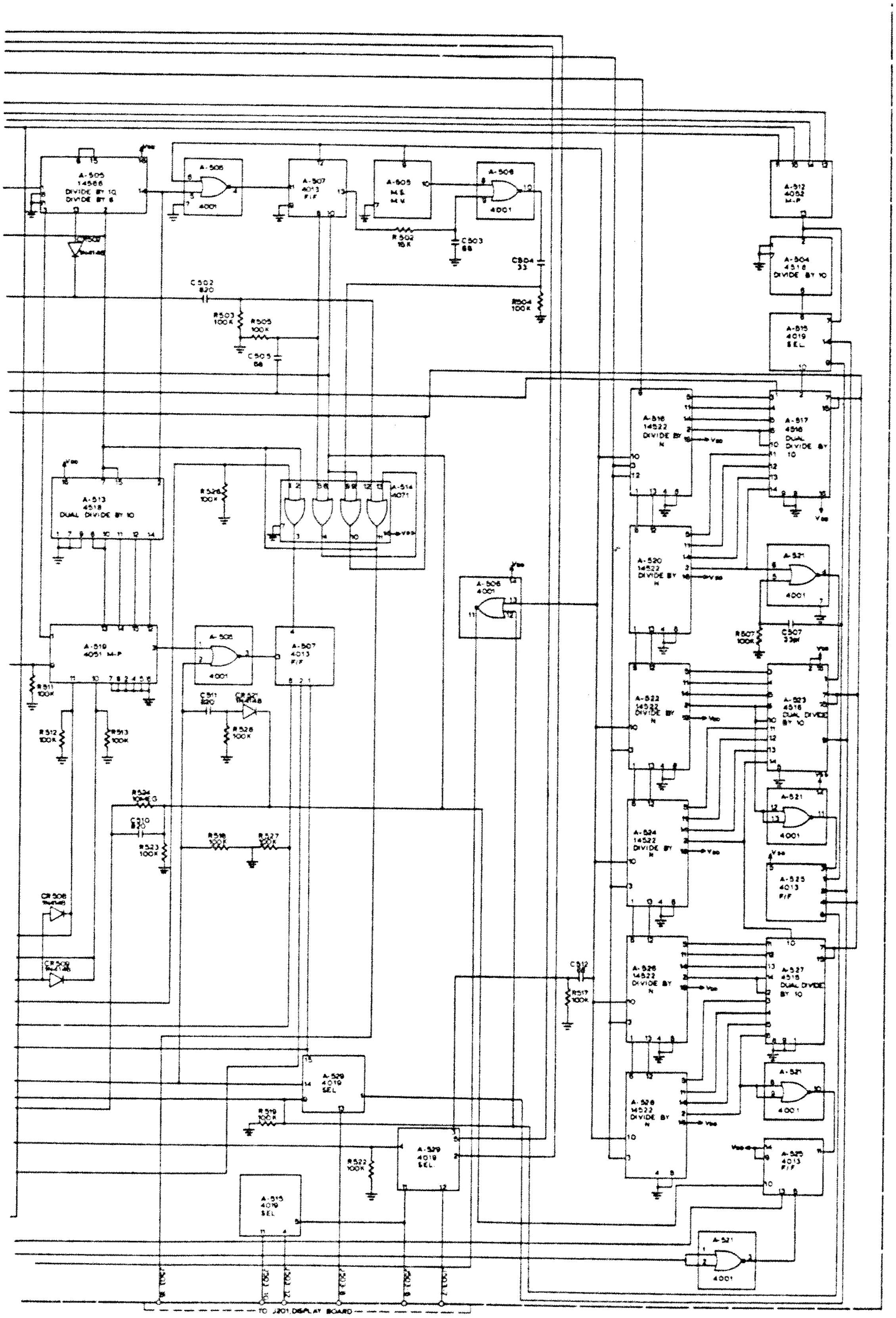


Figure 6-4. Main Board Schematic, Sheet 2 of 2 (10763-D76)

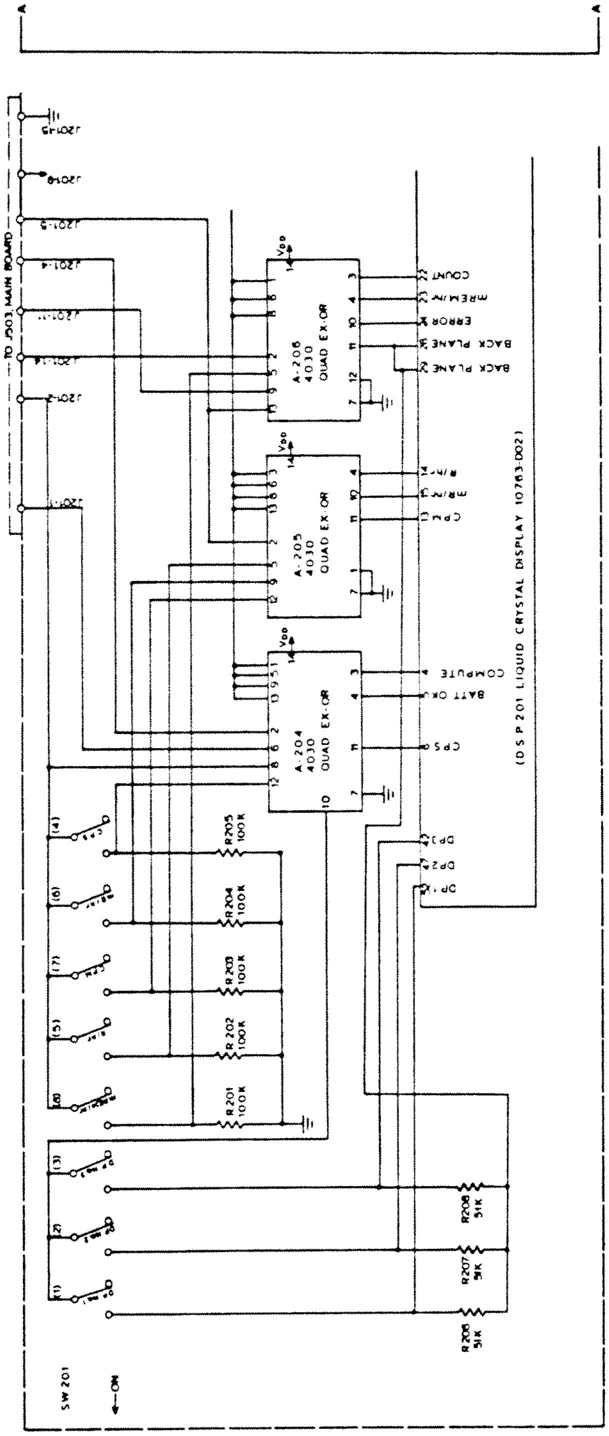


Figure 6-5. Display Board Schematic, Part 1 of 2 (10763-D77)

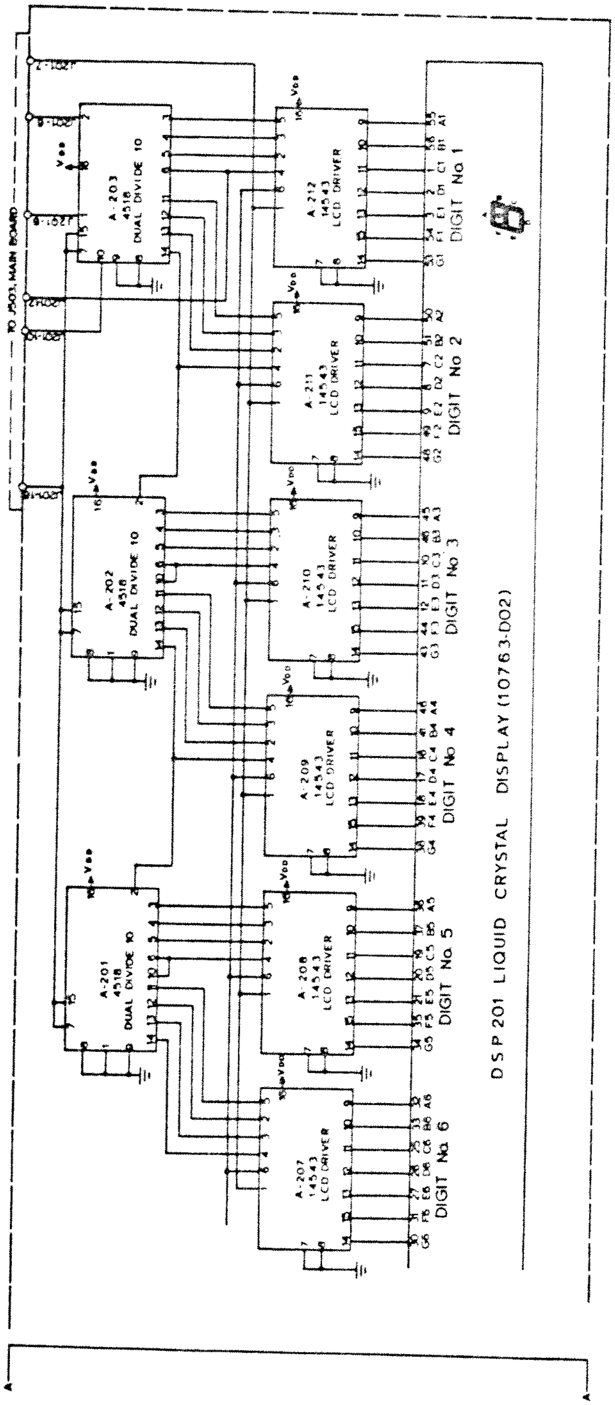


Figure 6-5. Display Board Schematic, Part 2 of 2 (10763-D77)

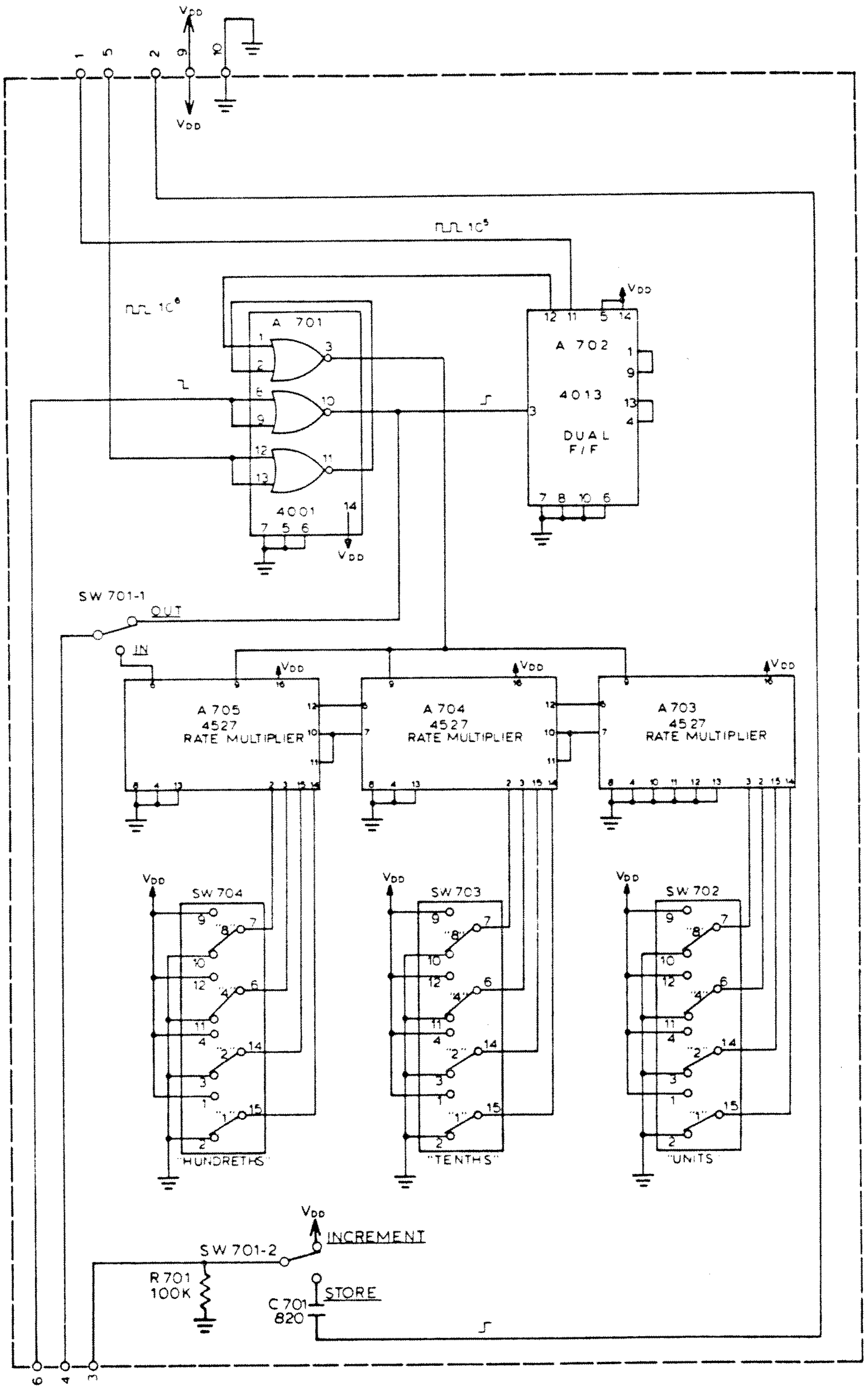


Figure 6-6. Rate Multiplier Board Schematic (10763-C78)

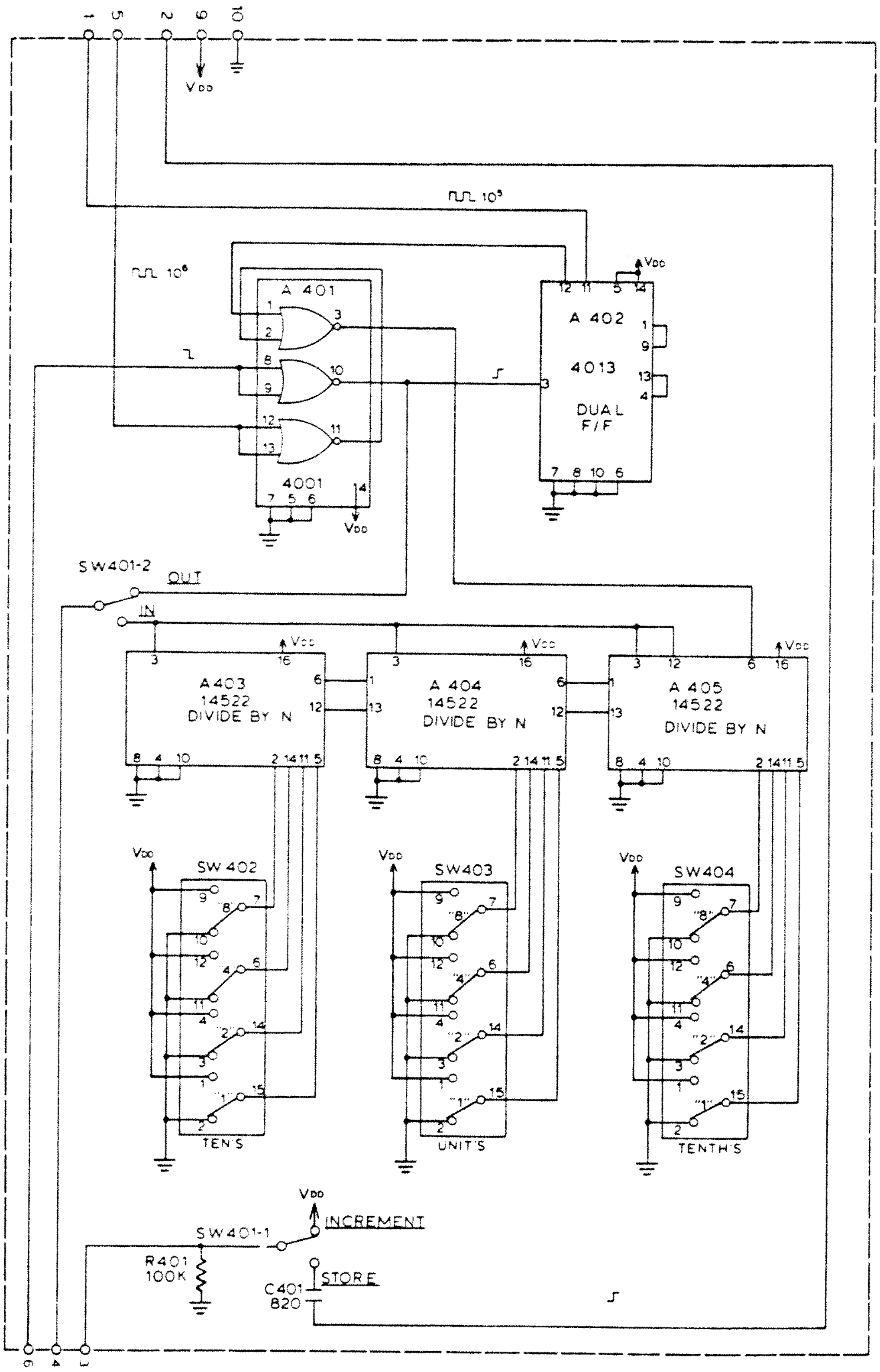


Figure 6-7. Rate Divider Board Schematic (10763-C79)

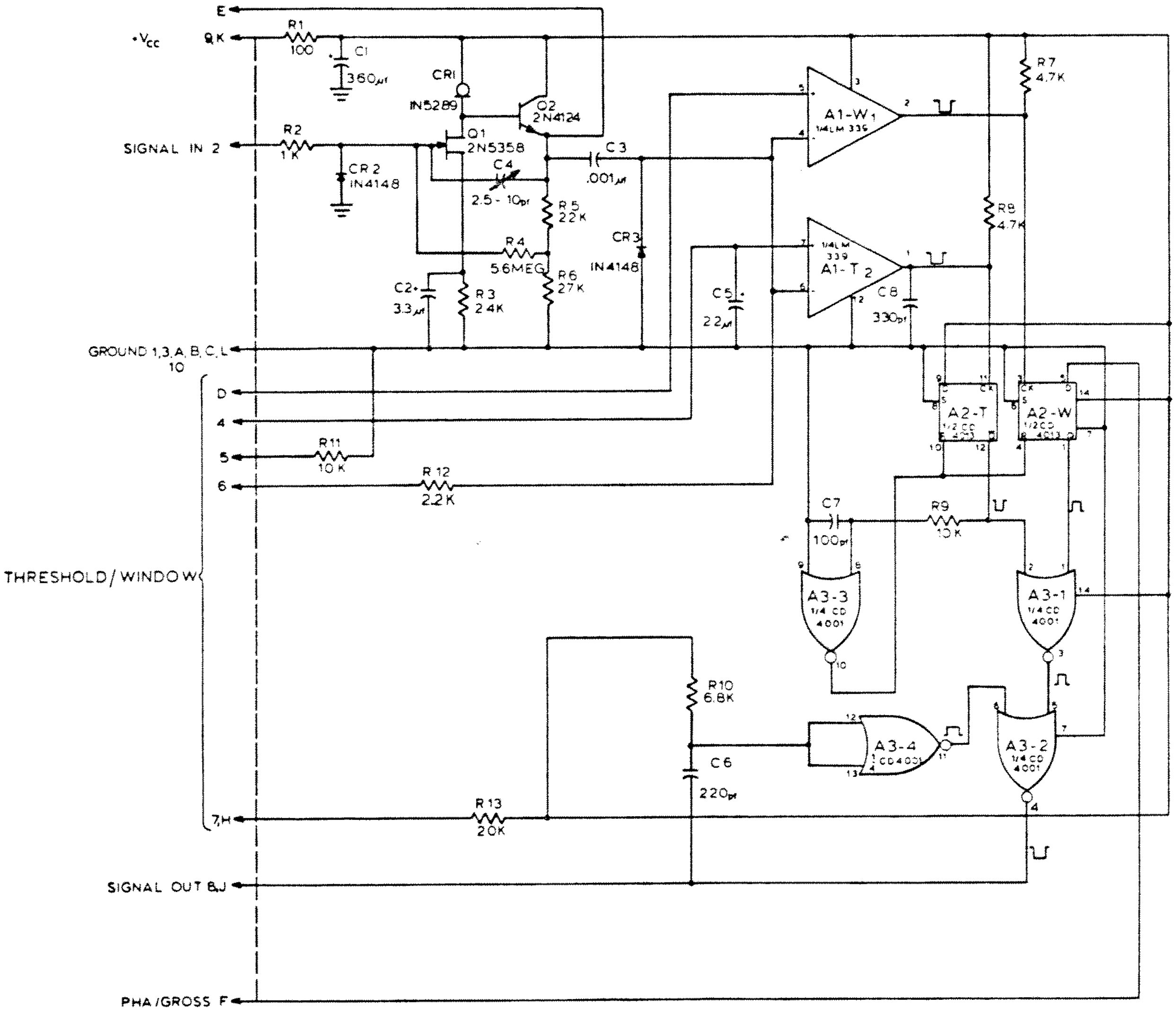
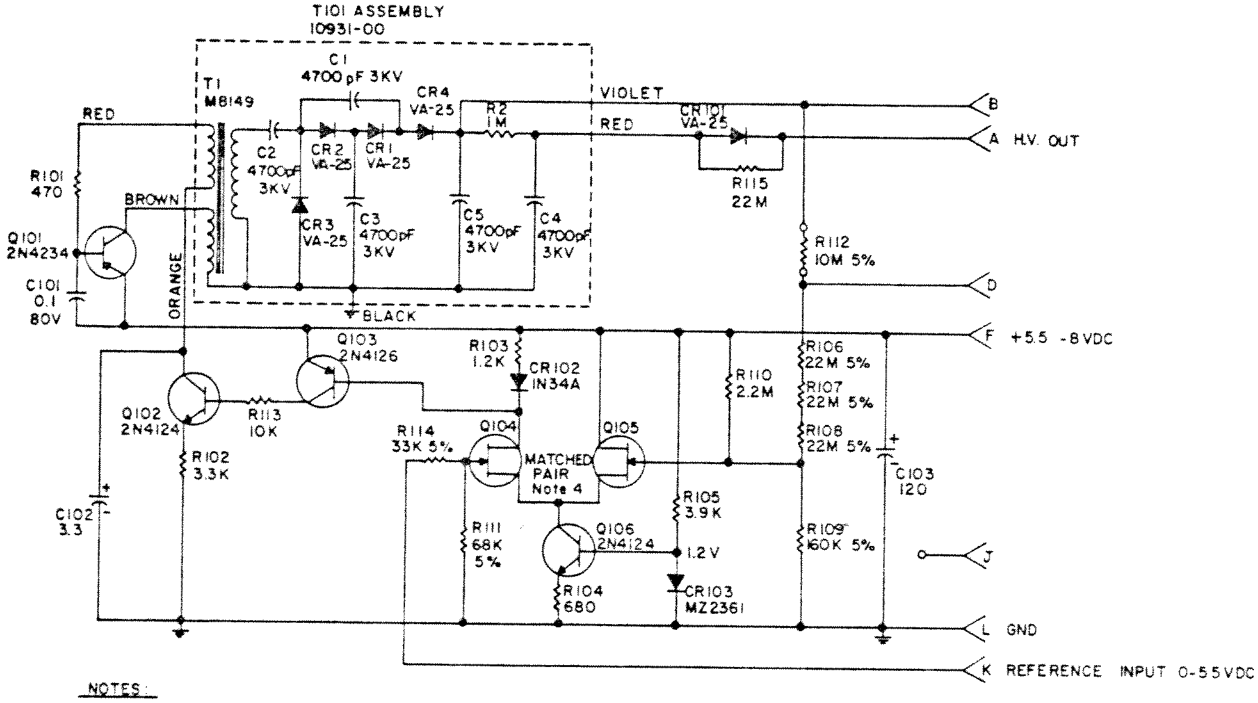


Figure 6-8. P-8B Schematic (10700-C05)



NOTES:

1. R112 MAY BE REPLACED BY A CORONA VR TUBE FOR HIGHER OUTPUT VOLTAGE.
2. STANDARD OUTPUT IS APPROX. 300 TIMES REFERENCE VOLTAGE.
3. FOR P-201AS REPLACE R112 WITH 22M AND REPLACE R109 WITH 110K.
4. Q104 and Q105 are EBERLINE P/N 10519-A04

Figure 6-9. P-201A Schematic (10519-C03M)

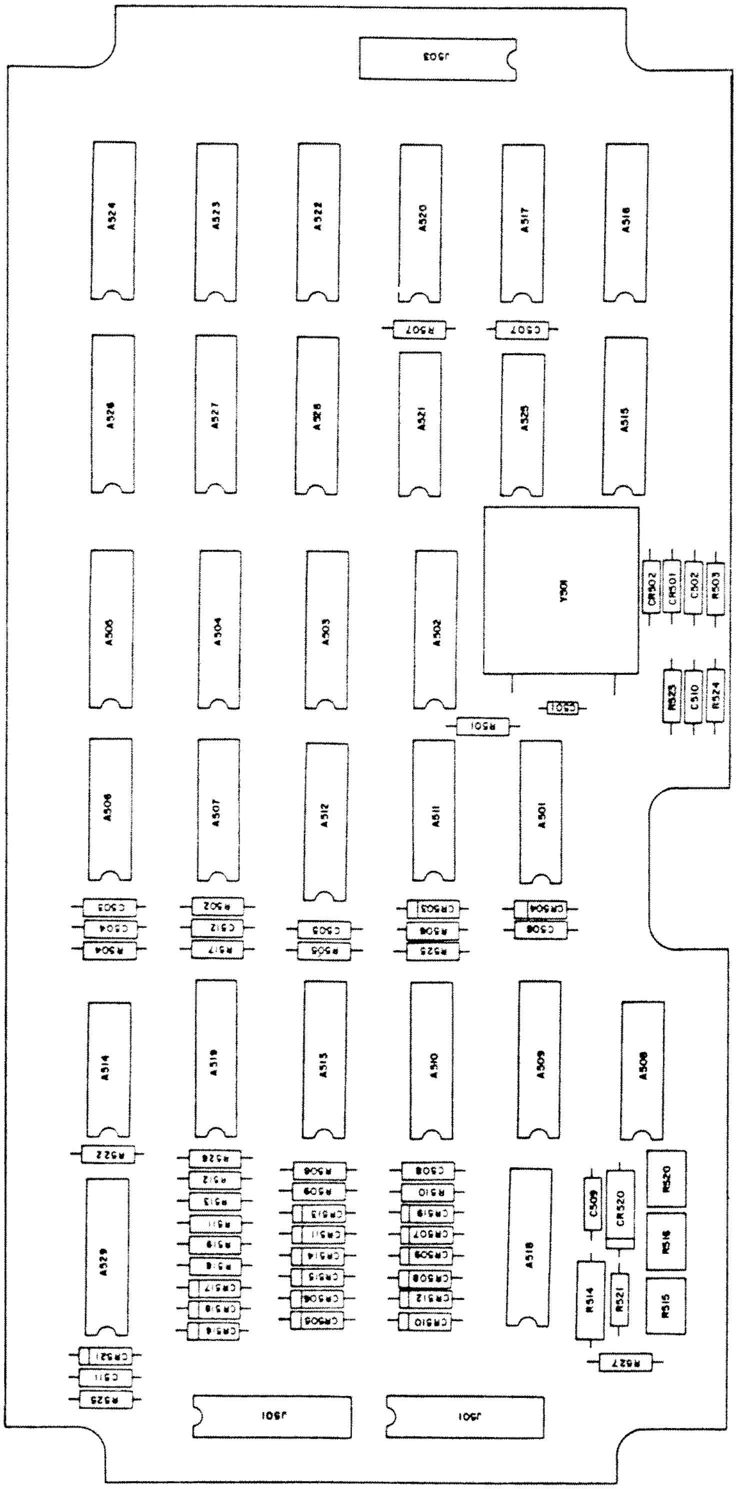


Figure 6-10. Main Board Component Layout (10763-D80)

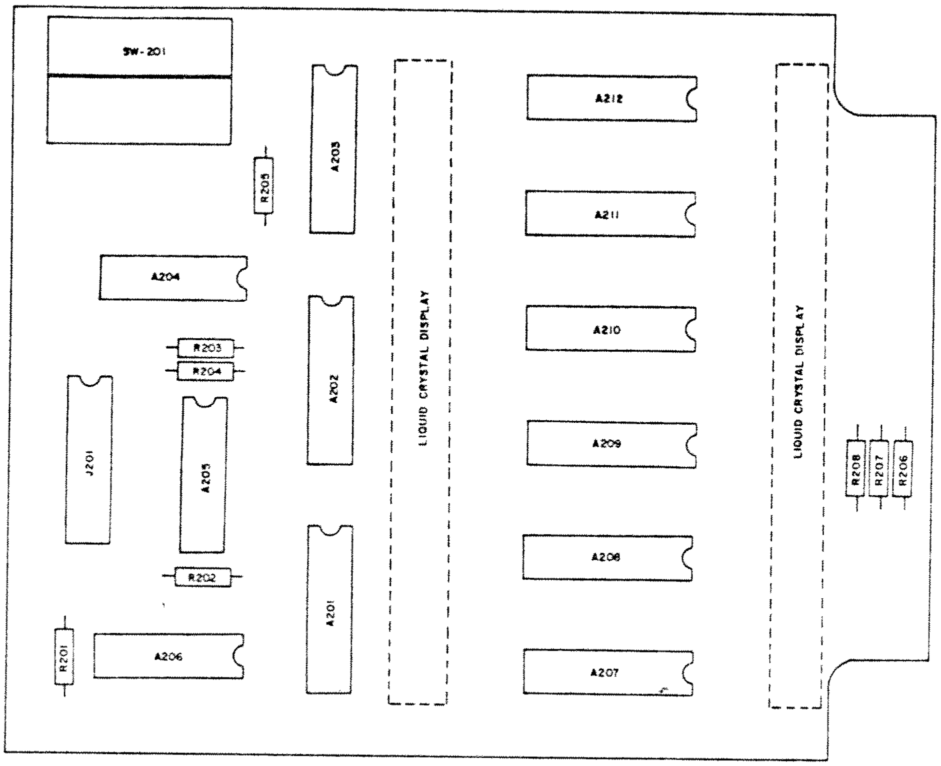


Figure 6-11. Display Board Component Layout (10763-C81)

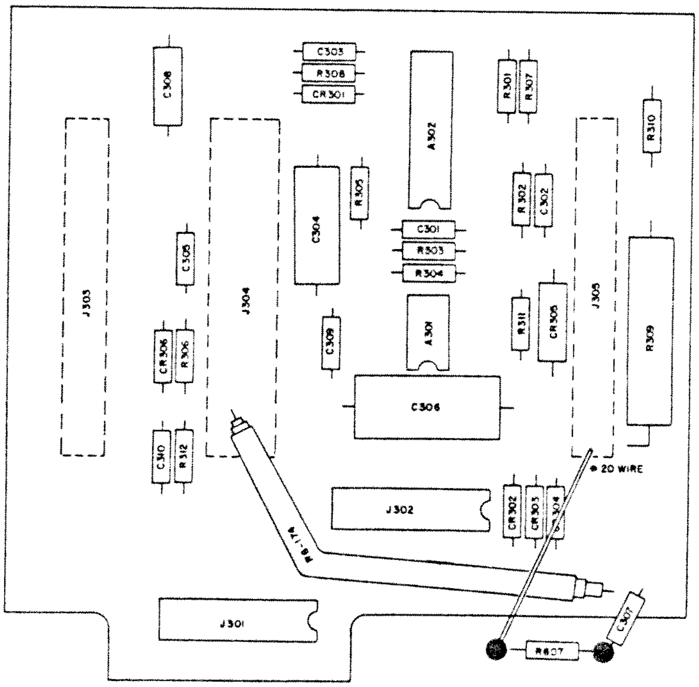


Figure 6-12. Mother Board Component Layout (10763-C82)

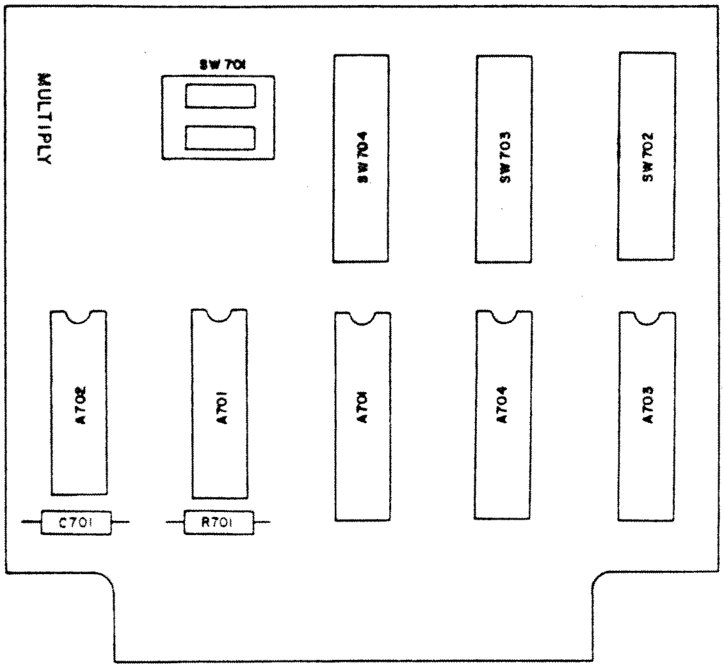


Figure 6-13. Rate Multiplier Component Layout (10763-C83)

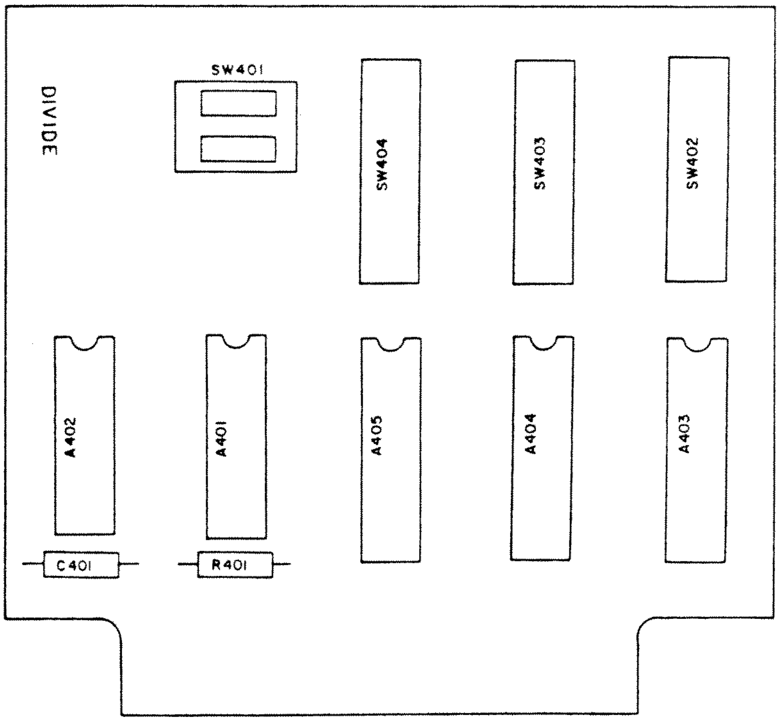


Figure 6-14. Rate Divider Component Layout (10763-C84)

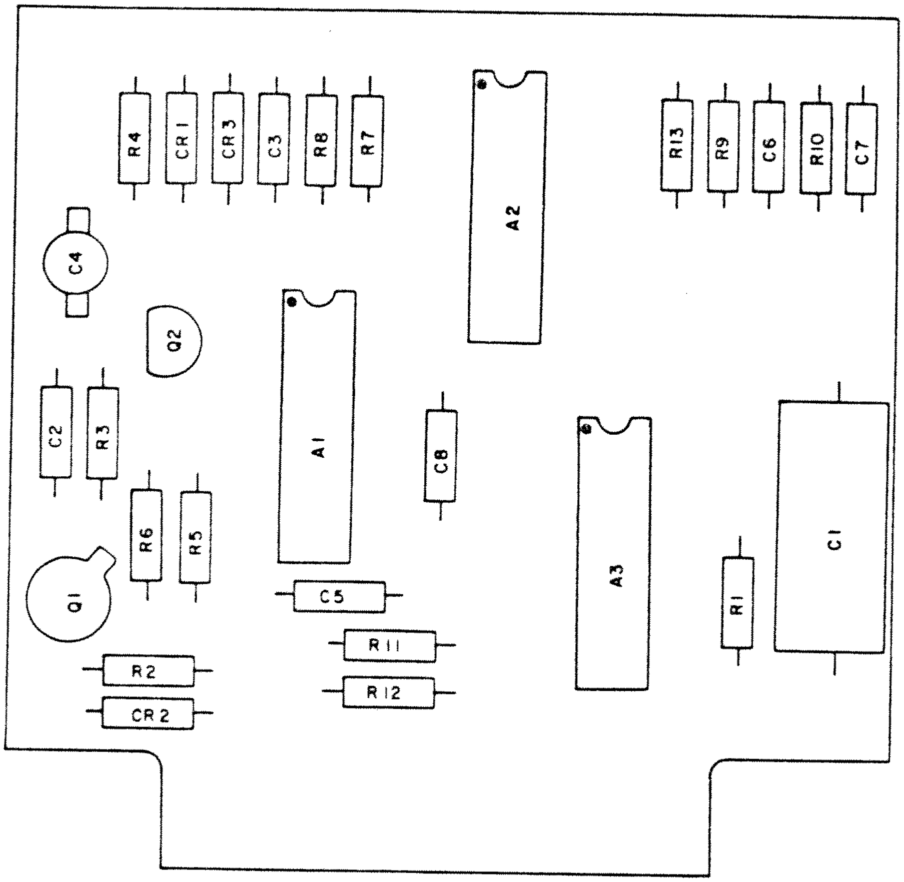


Figure 6-15. P-8B Component Layout (10700-C06)

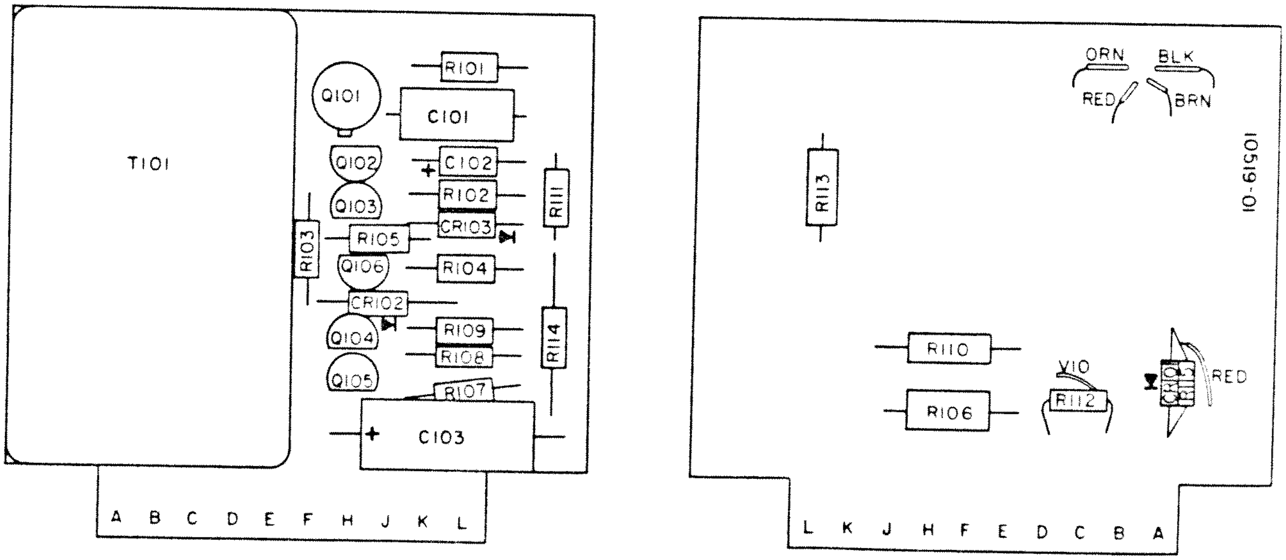


Figure 6-16. P-201A Component Layout (10519-C05)

CABLE INTERCONNECTIONS

J201 to J503
J301 to J501

NOTE:
Unless otherwise specified, on schematic diagrams in this manual, capacitor values greater than 1.0 are picofarads, capacitors values less than 1.0 are microfarads, resistor values are in ohms and fixed resistors are 1/8 W (on the P201A schematic diagram resistors are 1/4 W).

SECTION VII

APPENDIX I

PROBE: AC-3 Series

HIGH VOLTAGE: 800 — 1200 V typical.

THRESHOLD: 1.0 for PRS-1; 10 mV for PRS-2.

PHA-GROSS: GROSS for PRS-1; N/A for PRS-2.

CALIBRATION FOR: cpm correction for approximately 31 percent efficiency (-7 window from a 1 inch diameter or from 59 cm^2 of a large distributed area ^{239}Pu source).

DIVIDER: Not recommended.

MULTIPLIER: 3.22 — no decimal point used.

CALIBRATION FOR: cpm correction for approximately 20 percent efficiency (-8 window from a 1 inch diameter or from 59 cm^2 of a large distributed area ^{239}Pu source).

DIVIDER: Not recommended.

MULTIPLIER: 5.00 — no decimal point used.

APPENDIX II

PROBE: HP-270

HIGH VOLTAGE: 900 V.

THRESHOLD: 5.0 for PRS-1; 50 mV for PRS-2.

PHA-GROSS: GROSS for PRS-1; N/A for PRS-2.

CALIBRATION FOR: mR/h (approximately 1400 cpm/mR/h for ^{60}Co).

DIVIDER BOARD: 14.0 plus No. 2 decimal point.

MULTIPLIER BOARD: 0.71 plus No. 3 decimal point.

CALIBRATION FOR: mR/h (approximately 1200 cpm/mR/h for ^{137}Cs).

DIVIDER BOARD: 12.0 plus No. 2 decimal point.

MULTIPLIER BOARD: 0.83 plus No. 3 decimal point.

CALIBRATION FOR: cps (60 cpm = 1 cps).

DIVIDER BOARD: 06.0 plus No. 1 decimal point.

MULTIPLIER BOARD: 1.67 plus No. 2 decimal point.

NOTE: Other combinations of switch positions and decimal point selections may be chosen.

Example: For a division of 60 the divider and decimal point selection could be: 60.0 and no decimal point, 06.0 plus No. 1 decimal point or 00.6 plus No. 2 decimal point.

NOTE: The detector response at high rates is not linear due to detector dead time. The response of this detector is 20 percent below the true rate at an indication of 96 mR/h or 115,000 cpm, See Section II E.

APPENDIX III

PROBE: HP-190

HIGH VOLTAGE: 900 V.

THRESHOLD: 5.0 for PRS-1; 50 mV for PRS-2.

PHA-GROSS: GROSS for PRS-1; N/A for PRS-2.

CALIBRATION FOR: mR/h (approximately 3500 cpm/mR/h for ^{60}Co).

DIVIDER: 35.0 plus No. 2 decimal point.

MULTIPLIER: 0.28 plus No. 3 decimal point.

CALIBRATION FOR: mR/h (approximately 2500 cpm/mR/h for ^{137}Cs).

DIVIDER: 25.0 plus No. 2 decimal point.

MULTIPLIER: 0.40 plus No. 3 decimal point.

CALIBRATION FOR: cpm correction for approximately 45 percent efficiency (1 inch diameter source, 2π ^{90}Sr-^{90}Y [E max. 0.54-2.2 MeV]).

DIVIDER: Not recommended.

MULTIPLIER: 2.22 — no decimal point used.

CALIBRATION FOR: cpm correction for approximately 30 percent efficiency (1 inch diameter source, 2π ^{99}Tc [E max. 0.29 MeV]).

DIVIDER: Not recommended.

MULTIPLIER: 3.33 — no decimal point used.

CALIBRATION FOR: cpm correction for approximately 10 percent efficiency (1 inch diameter source, 2π ^{14}C [E max. 0.15 MeV]).

DIVIDER: Not recommended.

MULTIPLIER: 9.99 — no decimal point used.

NOTE: The detector response at high rates is not linear due to detector dead time. The response of this detector is 20 percent below the true rate at an indication of 23 mR/h or 57,000 cpm. See Section II E.

APPENDIX IV

PROBE: HP-230

HIGH VOLTAGE: 900 V.

THRESHOLD: 5.0 for PRS-1; 50 mV for PRS-2.

PHA-GROSS: GROSS for PRS-1; N/A for PRS-2.

CALIBRATION FOR: mR/h (approximately 2500 cpm/mR/h for ^{60}Co).

DIVIDER: 25.0 plus No. 2 decimal point.

MULTIPLIER: 0.40 plus No. 3 decimal point.

CALIBRATION FOR: mR/h (approximately 3000 cpm/mR/h for ^{137}Cs).

DIVIDER 30.0 plus No. 2 decimal point.

MULTIPLIER: 0.33 plus No. 3 decimal point.

CALIBRATION FOR: cpm correction for approximately 35 percent efficiency (0.8 inch source, 2π ^{90}Sr-^{90}Y [E max. 0.54-2.2 MeV]).

DIVIDER: Not recommended.

MULTIPLIER: 2.86 — no decimal point used.

CALIBRATION FOR: cpm correction for approximately 17 percent efficiency (0.8 inch source, 2π ^{99}Tc [E max. 0.29 MeV]).

DIVIDER: Not recommended.

MULTIPLIER: 5.88 — no decimal point used.

CALIBRATION FOR: cpm correction for approximately 10 percent efficiency (0.8 inch source 2π ^{14}C [E max. 0.15 MeV]).

DIVIDER: Not recommended.

MULTIPLIER: 9.99 — no decimal point used.

NOTE: The detector response at high rates is not linear due to detector dead time. The response of this detector is 20 percent below the true rate at an indication of 38 mR/h or 115,000 cpm, See Section II E.

APPENDIX V

PROBE: NRD

HIGH VOLTAGE: Typically 1600 to 2200 V.

THRESHOLD: 0.1 for PRS-1; 2 mV for PRS-2.

PHA-GROSS: GROSS for PHA-1; N/A for PRS-2.

CALIBRATION FOR: mrem/h (approximately 50 cpm/mrem/h).

DIVIDER: 05.0 plus No. 1 decimal point.

MULTIPLIER: 0.20 plus No. 1 decimal point.

NOTE: Other combinations of switch positions and decimal point selections may be chosen.

Example: For a division of 50, the divider and decimal point selection could be 50.0 and no decimal point, 05.0 plus No. 1 decimal point or 00.5 plus No. 2 decimal point; the multiplier could be 0.02 and no decimal point, 0.20 plus No. 1 decimal point or 2.00 plus No. 2 decimal point.

APPENDIX VI

PROBE: HP-290

HIGH VOLTAGE: 550 ±50 V.

THRESHOLD: 5.0 for PRS-1; 50 mV for PRS-2.

PHA-GROSS: Gross for PRS-1; N/A for PRS-2.

CALIBRATION FOR: mR/h (approximately 80 cpm/mR/h for ^{137}Cs).

DIVIDER: .08.0 plus No. 1 decimal point.

MULTIPLIER: 1.25 plus No. 2 decimal point.

NOTE: The detector response at high rates is not linear due to detector dead time. The response of this detector is 20 percent below the true rate at an indication of 7000 mR/h or 750,000 cpm. See Section II E.

NO.	JAN.	PER.	DESCRIPTION

CHG.	APP.	DATE	DESCRIPTION	DATE	BY	CH'K
F-1	ELB	3/22/84 4034	Pg 7, para. I-8, Added sensitivity specification for PRS-2	3/21/84	BC	Sonk
F	JBD	2/25/84 3869	MAJOR REVISIONS TO STEP Φ ADDED DATA SHEET FOR PRS-2P/NRD-1	1/28/84	JGS	JGS
E	ELB	10-20-83 2519 2972 3817	MAJOR REVISIONS TO TABLE I FOR CLARITY. ADDED B.6., SHEET 2 (SPEAKER ON) SHEET 2 NOTE ADDED - RETYPED	9/83	PM	ELB
D	ELB	1/25/82	Sheet 3: Step 5, was "2 less than 15 seconds," SHT 9 Added last sentence (Q5)	11/18/82	L D	HART
C	[illegible]	2/2/81	Step C.2. Added "Set the range switch to MAN."	1/27/81	QV	HART
B	[illegible]	6/8/78	Revise Par. 0 to inc. the following: HP270/270G with 1B85 tube), HP190, HP230A, AC-3-7, AC-3-8, HP220A, HP200, HP250, HP210/HP260, SPA-1, SPA-2 (all det.), SPA-3, LEG-1, PG-1/PG-2, RASP-1, Fiddler, RD13/RD14, TP-1, AC21, AC21B & AC23A.	6/7/78	GF	HB
A	RB	11/18/78	SHT 3: ITEM 5, WAS "RESET RATE CONTROL to CCW, 0.5 to 1.5 sec; CW, less than 15 seconds."	1-18-78	GF	HB

REV. A F APP. 2/28/84

EBERLINE INSTRUMENT CORPORATION
SANTA FE, NEW MEXICO

DR.	GF	12-12-77
CH'K.	Beene	12-13-77
PROJ. ENG.	Beene	12-13-77
APP.		12/13/77

PRS-1/PRS-2/PRS-1P/PRS-2P/PRS-2/NRD

CHECKOUT PROCEDURE

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	DEC.	ANG.
± 1/64	X.XX ± .015 X.XXX ± .005	± 1/2°

ALSO USED ON	EFF. WITH

SCALE

10429-A129 F

Sheet 1 of 14

This document is for Eberline in-house usage only and is subject to modification at any time. The process described herein is valid only if performed by Eberline personnel at Eberline facilities.

(NOTE: PRS-1 has PHA and GROSS switch, WINDOW and THRESHOLD controls; PRS-2 has only a THRESHOLD control--all other functions are the same. The PRS-1P, PRS-2P and PRS-2/NRD use P-201AS high voltage power supply.)

A. Preliminary Setup

1. P-201A (or P-201AS) removed.
2. Battery Pack removed.
3. Speaker switch OFF.
4. Range switch OFF.
5. Reset Rate switch in extreme counterclockwise (ccw) position.
6. Adjust external DC power supply for 6.25 V and connect to Battery Pack terminals. OBSERVE POLARITY.

NOTE: If this instrument shows feedback problems, or is to be used with detectors which give a weak signal, refer to document 16000-A02 for modification instructions.

B. Preliminary Tests

1. Place the range switch in the High Voltage position--all six digits should indicate and the COUNT legend should flash at a nominal 1 second rate. The BATTery OK and the ERROR legend may indicate; other legends should not indicate.
2. Place the range switch in a timed position. Use a frequency counter with a 10k isolation resistor and measure the frequency at Pin 5 of the Calibration Board socket (Mother Board). The frequency should be 1.000 MHz ±0.05 percent (0.99995 to 1.00005 MHz).
3. Use an oscilloscope with a high impedance probe and measure the frequency at Pin 6 of A-212 (Display Board, right hand side). Frequency should be 100 Hz with an amplitude of at least 5.5 V.
4. Measure power supply current. With the P-201A (or P-201AS) removed, the current should be less than 10 mA. Press the LIGHT switch; the current should be less than 85 mA and lamp should light.
5. Place the range switch in Position A and check legend display vs. legend switch position (Display Board). The proper legend should appear when the selected switch is closed and not appear when the switch is open.
6. Switch speaker switch to ON.

C. Scaler

1. Adjust the output of an MP-1 to 1 V and connect it to the instrument. Place the PHA-GROSS switch to GROSS, the THRESHold control to 1.0, the SCALER switch (Calibration Board) to INCRement and the range switch to 0.5. (For PRS-2, set THRESHold control to mid-range. No PHA-GROSS SWITCH ON PRS-2.)

2. Press the RESET switch; the instrument should count. Set the range switch to MAN. Adjust the MP-1 rate to suitable ranges and check all seven segments of each digit.

3. Adjust the MP-1 for 100,000 counts per minute (cpm) and check each timed position. The count should be:

   0.5 - Count = 49,943 to 50,057
   1 - Count = 99,887 to 100,113
   2 - Count = 199,775 to 200,225
   5 - Count = 499,439 to 500,561

   The COUNT legend should be displayed when the instrument is counting.

4. Check MANual and STOP switch positions for proper operation. The COUNT legend should be displayed when the instrument is counting.

5. Place the range switch in the 0.5 position. Rotate the reset rate clockwise (cw) out of the switch detent. Start the Scaler by pressing the RESET button. At the completion of the timed period, the instrument should automatically reset as follows: Reset RATE control cw, 0.5 to 1.5 seconds; ccw, less than 20 seconds. Return control to maximum ccw position.

6. Place the SCALER switch (Calibration Board) in the STORE position. Adjust the MP-1 for a value different from that shown on the display and press the instrument RESET switch. Display should update at the end of the timed period.

D. Rate Meter

1. Place the CALIBration switch (Multiply or Divide Board) in the OUT position. Connect an MP-1 to the instrument and check range switch positions: "A" 10 cpm to 800 cpm, "B" 200 cpm to 8k cpm, "C" 2k cpm to 80k cpm and "D" 20k cpm to 800k cpm. Use Table 1 below to check

the results. Check that the COUNT legend is displayed during the counting function and that the COMPUTE legend is displayed during the computing function (3 seconds).

2. Use a pulse generator to obtain the frequencies listed in Table 2 below and check with the range switch in position A or B. The exact reading is not important but an incorrect reading of over 100 percent will indicate a problem in the instrument.

3. Place the range switch in the A position and the MP-1 in MANual. Press the MANual switch on the MP-1 -- the COUNT must be displayed. Wait 1 minute, 42 seconds and the ERROR legend should appear. Press the RESET switch and the ERROR legend and the COUNT legend should extinguish.

TABLE NO. 1

INPUT (cpm)	COUNT TIME FOR SWITCH POSITIONS (SECONDS)				MAXIMUM READING	MINIMUM READING
	A	B	C	D		
800,000				0.75	810,820	779,210
400,000				1.5	402,690	394,720
200,000				3	200,670	198,660
100,000				6	100,170	99,650
80,000			0.75	7.5	80,110	79,770
40,000			1.5	15	40,269	39,472
20,000			3	30	20,067	19,866
10,000			6		10,017	9,965
8,000		0.75	7.5		8,011	7,977
4,000		1.5	15		4,004	3,993
2,000		3	30		2,004	1,997
1,000		6			1,002	995
800	0.75	7.5			802	796
400	1.5	15			402	396
200	3	30			201	197
100	6				101	98
80	7.5				81	78
40	15				41	38
20	30				21	18
10	60				11	8

TABLE NO. 2

INPUT FREQUENCY	DISPLAY
11.200 to 12.500 KHz	672,000 to 800,000
1.200 to 1.250 KHz	67,200 to 80,000
120 to 125 HZ	6,720 to 8,000
12.0 to 12.5 Hz	672 to 800
1.20 to 1.25 Hz	67 to 80

E. Calibration Function (A Multiply or Divide Board may be used. The Multiply Board is standard.)

1. Place the CALIBration switch in the IN position and place the range switch in Position A. Adjust an MP-1 for 10,000 cpm at 1 - 3 V and connect to the instrument.

2. For the Rate Multiplier, set the calibration switches for 1.00. For the Rate Divider, set the calibration switches for 10.0.

3. Starting with the first calibration switch, check each position of the switch 1 through 9 for proper display (Example: If the switch position is 5 on a Rate Divider, then the display should read 1/50th of what the display indicated with the CALIBration switch in the OUT position.) Then place the first switch in the 0 position and check each position of the second switch 1 through 9. Repeat for the third switch.

4. The division or multiplication should be within 5 percent of the original number.

F. Speaker

Adjust the SPKR ON switch to SPKR ON. At rates below approximately 10,000 cpm clicks at the input rate should be heard. At rates above 40,000 cpm a steady 2 KHz tone should be heard (any position of the range switch except OFF).

G. Battery Condition Indicator

Place the range switch in the High Voltage position (P201A need not be installed). Adjust BATTery OK ADJust pot, R520, such that the BATTery OK legend is displayed when the power supply (connected in place of the battery) is adjusted to 5.75 V and the legend is not displayed at 5.60 V. When the BATTery OK legend is not displayed, the ERROR legend should be displayed. When the BATTery OK legend is displayed, the ERROR legend should not be displayed. When the BATTery OK legend is displayed, the ERROR legend should not be displayed (It may be necessary to press the RESET switch).

H. P-8B

With P-201A (or P-201AS) installed, adjust P-8B GAIN for 8 to 12. Set MP-1 for 10 mV and observe an 80-120 mV signal at Pin 4 of A1 (LM339). Do not use card extender on P-8B for this adjustment. The range of adjustment should be approximately 8-12 mV or more. Use a high impedance probe on the oscilloscope for this measurement.

I. Sensitivity

1. Place the SCALER switch to INCRement (on the Rate Multiplier or Rate Divider Board).
2. Connect an MP-1 to the instrument and adjust the MP-1 to minimum output.
3. Place the instrument range switch to MANual and the PHA-GROSS switch to GROSS.
4. Adjust the THRESHold control to 0.00.
5. If the instrument is counting, rotate the THRESHold cw, slowly, until the counting stops.
6. Increase the output of the MP-1 until the instrument starts counting. The instrument should start counting at 2-2.5 mV.
7. Adjust the THRESHold control to maximum cw position. The instrument should stop counting.
8. Increase the output of the MP-1 until the instrument starts counting. The instrument should start counting between 90 to 110 mV, PRS-1 and between 14 to 22 mV, PRS-2.

J. PHA (PRS-1 only)

1. Place the SCALER switch to INCRement (on the Rate Multiplier or Rate Scaler Board).

2. Connect an MP-1 to the instrument and adjust the MP-1 to minimum output.

3. Place the instrument range switch to MANual and the PHA-GROSS switch to PHA.

4. Place the THRESHold control to 5.0 and the WINDOW to 5.0. Instrument should start counting at 50 ±10 mV and stop counting at 100 ±20 mV.

5. Place the THRESHold control to 5.0 and the WINDOW to 2.5. The instrument should stop counting at 75 ±15 mV.

6. Place the THRESHold control to 2.5 and the WINDOW to 2.5. The instrument should count between 25 ±10 mV and 50 ±20 mV.

7. Place the THRESHold control to 7.5 and the WINDOW to 2.5. The instrument should count between 75 ±10 mV and 100 ±20 mV.

8. Set THRESHold to 1.0 and WINDOW to 1.0.

K. Light

1. Press LIGHT switch; light should operate.

2. Electrical noise, or extra counts, should not occur when the LIGHT switch is operating.

3. The ERROR legend should not appear when the switch is operated (low battery is probable if ERROR legend appears).

L. Legend Switch

1. Place the range switch in a rate meter position, A through D.

2. Operate each legend switch separately and observe that the legend activated agrees with legend decal on the side of the instrument chassis.

M. High Voltage Voltage Controlled Oscillator

1. Position the range switch to OFF and install the P-201A (or P-201AS). Connect a suitable voltmeter to the detector connector.

2. Place the range switch in the High Voltage position. Adjust the High Voltage ADJust for 1500 V on the external meter and adjust the VCO FREQUENCY control, R515, for a reading of 1500 ±30 on the display. Adjust the High Voltage ADJust for 500 V and adjust the VCO OFFSET control, R516, for a reading of 500 ±15 on the display. These controls are interactive and the above adjustments may have to be repeated. Check in the instrument at 1000 ±50.

   NOTE: If a P-201AS is installed or if a voltmeter range of 800-2400 V is specified, a resistor of 4.32 M ohm must be placed in parallel with R310 and the voltmeter calibrated for an 800-2400 V range. Repeat the procedures in Paragraphs 1 and 2 above, substituting 800 ±24 and 2400 ±48 for 500 ±15 and 1500 ±30 respectively. Check at 1700 ±50 V. Consult the nomenclature sheet for resistor specifications.

N. Battery Pack

1. Place the range switch in the OFF position, disconnect the external power supply and connect the specified Battery Pack (Gell-Cell Battery Pack is normal, BP1-1 and BP1-4 are options).

2. Place the range switch in the High Voltage position and check instrument operation (BATTery OK, High Voltage DISPLAY, etc.).

3. If the Battery Pack is of the rechargeable type, connect the Battery Charger. The instrument should not function. Place the range switch in the OFF position and check the operation of the Battery Charger. (The battery terminal voltage should increase when the charger is connected.) Charge batteries for a period of 12-48 hrs. Do not exceed 48 hr charge period.

O. Instrument Setup (Unless specified by the shipping order or job order, set the instrument as follows:)

1. Use the following table to match the instrument to the specified probe.

Probe	High Voltage	Multiplier	Decimal Point	Divider	Decimal Point	Legend
HP270/HP270G	900	0.83	No. 3	12.0	2	mR/hr
(w/ 1B85 Tube)	900	0.31	No. 3	32.0	2	mR/hr
HP190	900	1.00	None	01.0	None	cpm
HP230A	900	1.00	None	01.0	None	cpm
AC-3-7	800-1200	3.22	None	----	----	cpm
AC-3-8	800-1200	5.00	None	----	----	cpm
NRD-1	1600-2200*	0.20	No. 1	05.0	No. 1	mrem
No probe specified	900	1.00	None	01.0	None	cpm
HP220A	600	1.00	None	01.0	None	cpm
HP200	600	1.00	None	01.0	None	cpm
HP250	900	0.90	No. 2	11.0	No. 1	mR/hr
HP210/HP260	900	1.00	None	01.0	None	cpm
SPA-1	800-1200	4.00	None	----	----	cpm
SPA-2 (all det)	800-1200	1.00	None	01.0	None	cpm
SPA-3	800-1200	1.00	None	01.0	None	cpm
LEG-1	800-1200	1.00	None	01.0	None	cpm
PG-1/PG-2	800-1200	1.00	None	01.0	None	cpm
RASP-1	800-1200	1.00	None	01.0	None	cpm
Fiddler	800-1200	1.00	None	01.0	None	cpm
RD13/RD14	800-1200	1.00	None	01.0	None	cpm
TP-1	2500-3000**	1.00	None	01.0	None	cpm
AC21	1000-2000*	2.00	None	00.5	None	cpm
AC21B	1500-2500*	1.00	None	01.0	None	cpm
AC23A	1000-2000*	3.00	None	00.3	None	cpm

*Use P-210AS power supply. Refer to Paragraph M.
**P201 as modified to 2900 volts.

2. Set the SCALER switch on the Multiply Board (or Divide Board) to INCRement and the CALIBration switch to IN.

P. PRS-1/PRS-2 Threshold Adjustment

1. For proportional detectors, adjust the THRESHold control for 2-2.5 mV sensitivity.

2. For scintillation detectors, adjust the THRESHold control for 6-7 mV sensitivity.

3. For G-M detectors, adjust the THRESHold control for mid-range.

NOTE: The PRS-2P and the PRS-2/NRD instruments should be adjusted as per Step 1 above.

Q. Calibration of PRS-2/NRD and NRD-1 Detector

1. Select the internal controls as follows:

Calibration Function Switch OUT
Legend Switch Select units CPM switch 7 all other switches open

2. Adjust THRESHold for 2-2.5 mV sensitivity without the power supply installed.

3. Install P-201AS power supply and calibrate High Voltage position per Step M of this procedure. Adjust High voltage ADJust to about 1900 V.

4. Connect an NRD-1 detector and place the detector in 10 R/h ^{137}Cs field. The distance to the center of the detector is 13 cm. Subtract this value from the 10 R/h source distance to give the height the source needs to be positioned to, that will yeild 10 R/h field at the center of the NRD-1 tube. Turn on the speaker, select Rate A position and increase the High Voltage ADJust until about one click per second is heard on the speaker, note the high voltage value. This corresponds to a countrate of about 60 cpm. Reduce the High Voltage by 50 V and lock the control, record the high voltage.

5. Place the instrument in a 27 mrem/h field on the neutron source well. The calibrated distances on this well take into account the 13 cm height of the NRD-1 detector. Select the 5 minute position in the scaler mode and take a 5 minute count. Divide the observed number by 1350 to obtain the calibration factor (1350 is the product of 27 mrem/hr x 5 minute count time x 10). The factor of 10 yields a calibration factor that is within the desired range of selection. The decimal point 1 must be selected on the Legend Switch.

$$\frac{\text{Count in 5 minutes}}{1350} = \text{Calibration factor}$$

For a rate divider use the calculated value. The value must be between 04.2 to 06.3.

For a rate multiplier use the reciprocal of the calculated value. The value must be between 0.16 to 0.24.

6. Record the calibration factor and enter this value on the multiplier board by switching the calibration function switches. Select units of mrem/h by switching 7 open and 8 closed on the LEGEND SWITCH. Switch the CALIBRATION FUNCTION IN-OUT SWITCH to IN.

7. Place the NRD-1 in a 27 mrem/h field on the neutron source well. The PRS-2P should read 25.6 to 28.4 mrem/h (27 mrem/h ± 5 percent). This should be done in the Rate C position. Record the actual value.

8. Check the calibration at a second point by placing the NRD-1 in a 100 mrem/h field on the neutron source well. The PRS-2P should read 90 to 110 mrem/h (100 mrem/h ± 10 percent). This should be done in the rate C position.

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CALIBRATION DATA SHEET

PRS-2P/NRD-1 Serial No. ______________

Calibration performed on Eberline Neutron Source Well which contains PuBe Source Serial No. EI-143.

Q.4. High Voltage ________________________ Volts D.C.

Q.5. Five Minute Count Value ______________ at 27 mrem/h

Q.6. Calibration Factor [a) or b)]

a) For Rate Divide Board ________________

b) For Rate Multiplier Board _____________

Q.7. Calibration

Field	Actual Reading
27 mrem/h	__________ mrem/h
100 mrem/h	__________ mrem/h

By____________________________

Date __________________________

Quality Control ____________________

Date _____________________________